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16. ABSTRACT

In response to the threat to human health and the environment posed by numerous uncontrolled hazardous waste sites across the country, new remedial action technologies are evolving and known technologies are being retrofitted and adapted for use in cleaning up these sites. This report identifies and assesses various types of site response activities which have been implemented, are in progress, or have been proposed to date at Superfund-financed and enforcement action hazardous waste sites in the United States. A nationwide survey was conducted in which 30 uncontrolled hazardous waste sites were identified where either some form of enforcement action was planned or where remedial actions were Superfund-financed. Based on an assessment of the 30 sites, eight sites were selected for which detailed case study investigations have been conducted. This document presents case study reports for each of the eight sites. These reports include extensive discussions of the remedial responses at each of the eight sites with respect to technology, cost, and institutional framework.

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CASE STUDIES ADDENDUM: 1-8
REMEDIAL RESPONSE AT HAZARDOUS WASTE SITES

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FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of solid and hazardous wastes. These materials, if improperly dealt with, can threaten both public health and the environment. Abandoned waste sites and accidental releases of toxic and hazaradous substances to the environment also have important environmental and public health implications. The Hazardous Waste Engineering Research Laboratory assists in providing an authoritative and defensible engineering basis for assessing and solving these problems. Its products support the policies, programs and regulations of the Environmental Protection Agency, the permitting and other responsibilities of State and local governments and the needs of both large and small businesses in handling their wastes responsibly and economically.

As part of ongoing research and development of existing and emerging technologies for use in the remediation of uncontrolled hazardous wastes released to the environment, a study was completed and published in March 1984 which involved a survey of uncontrolled hazardous waste sites nationwide, and 23 detailed case study reports were prepared. Compiled into succinct case study reports, this historical information can then be used in planning, selecting, designing, and cost analyzing future remedial actions. The preparation of the eight case studies included in this document, is a continuation of the research and preparatory activities involved with the initially published 23 reports. The focus of this more recent series of eight case studies, however, is on Superfund-financed or enforcement action sites, as opposed to the previous studies which focused on private- and State-led actions. The case study reports are intended for use by EPA regional officials, state agencies, industry and commerce, and local authorities involved in selection, evaluation and design of remedial response actions.

Thomas R. Hauser, Director
Hazardous Waste Engineering Research Laboratory

ABSTRACT

In response to the threat to human health and the environment posed by numerous uncontrolled hazardous waste sites across the country, new remedial action technologies are evolving and known technologies are being retrofitted and adapted for use in cleaning up these sites. This report identifies and assesses various types of site response activities which have been implemented, are in progress, or have been proposed to date at Superfund-financed and enforcement action hazardous waste sites in the United States. A nationwide survey was conducted in which 30 uncontrolled hazardous waste sites were identified where either some form of enforcement action was planned or where remedial actions were Superfund-financed. Based on an assessment of the 30 sites, eight sites were selected for which detailed case study investigations have been conducted. This document presents case study reports for each of the eight sites. These reports include extensive discussions of the remedial responses at each of the eight sites with respect to technology, cost, and institutional framework.

This report was submitted in fulfillment of Contract No. 68-03-3113, Task 39-4 by SAIC/JRB under the sponsorship of the U.S. Environmental Protection Agency.

CONTENTS

Foreword iii
Abstract iv
Abbreviations and Symbols. vi
Acknowledgements vii

I. Executive Summary viii

II. Case Study Reports

1. Bruin Lagoon, Bruin Borough, PA 1-1
2. Denney Farm, Barry County, MO 2-1
3. Gulf Coast Lead, Tampa, FL. 3-1
4. Lipari Landfill, Pitman, NH 4-1
5. Picillo Farm, Coventry, RI. 5-1
6. Rose Park Sludge Pit, Salt Lake City, UT. 6-1
7. Tacoma Well 12A, Tacoma, WA 7-1
8. Taylor Road Landfill, Seffner, FL 8-1

LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

ASTM	- American Society for Testing and Materials
BTU/lb	- British thermal units per pound
°C	- degrees Centigrade
cm	- centimeter
cm^3	- cubic centimeter
COD	- chemical oxygen demand
COD	- chemical oxygen demand
EP toxic	- extraction procedure toxic
gpd	- gallons per day
gpl	- gallon per liter
gpm	- gallon per minute
ha	- hectare
kg	- kilogram
kg/m^3	- kilogram per cubic meters
kwh	- kilowatt hour
khw/year	- kilowatt hour per year
l	- liter
LL	- liquid limit
m	- meter
m^2	- square meter
m^3	- cubic meter
mg	- milligram
mg/l	- miligram per liter
ml	- milliliter
mt	- metric ton
NaPEG	- sodium polyethylene glycol
NCP	- National Contingency Plan
NPDES	- National Pollution Discharge Elimination System
Pa	- pascal
pcf	- pounds per cubic foot
PL	- plastic limit
POTW	- publicly owned treatment works
ppb	- parts per billion
ppm	- parts per million
psi	- pound per square inch
RCRA	- Resource Conservation and Recovery Act
STP	- sewage treatment plant
tcdd	- tetrachlorodibenzodioxin
TICH	- total identifiable chlorinated hydrocarbons
TOC	- total organic carbon
TSCA	- Toxic Substances Control Act
TSS	- total suspended solids
ug	- microgram
ug/g	- microgram per gram
ug/l	- microgram per liter

SYMBOLS

$Ca(OH)_2$	- calcium hydroxide
Cao	- calcium oxide
$CaCO_3$	- calcium carbonate
<	- greater than
>	- less than

ACKNOWLEDGEMENTS

Science Applications International Corporation/JRB Associates (SAIC/JRB) and the Environmental Law Institute (ELI) prepared this report for EPA's Hazardous Waste Engineering Research Laboratory, the Office of Emergency and Remedial Response, and the Office of Waste Programs Enforcement. This report was prepared through the coordinated efforts and guidance of Claudia Furman, SAIC/JRB Project Manager; S. Robert Cochran; Roger Dower, ELI Project Manager; and Dr. Edward Yang. The following persons from SAIC/JRB and ELI all played major roles in conducting the initial survey, case study site selection, case study site visits, and report preparation: Durk Bouma, Richard Eades, Mark Evans, Linda Schwartz, Edward Tokarski, Kathleen Wagner, and Al Wickline.

The project team wishes to acknowledge and thank Douglas Ammon, Bruce Clemens, John Cross, and Stephen James, EPA Task Managers, and Donald Sanning, overall EPA Project Officer, for their assistance and support in developing this document. We also acknowledge those USEPA, state and local authorities for their cooperation and support during our data collection efforts and for their review of the eight case study reports.

I. EXECUTIVE SUMMARY

1.0 INTRODUCTION

As part of ongoing research and development of existing and emerging technologies for use in the remediation of uncontrolled hazardous wastes released to the environment, a study was completed and published in March 1984 which involved a survey of uncontrolled hazardous waste sites nationwide, and the preparation of 23 detailed case study reports. The objective of the survey and the preparation of the case studies has been to identify, examine and quantify the different types of remedial response actions that have been implemented, proposed or are in progress at sites throughout the United States. Detailed information has been collected on cost, institutional and technical issues related to the implementation and effectiveness of remedial responses at these sites. Compiled into succinct case study reports, this historical information can then be used in planning, selecting, designing, and cost analyzing future remedial actions.

The preparation of the eight case studies included in this document, is a continuation of the research and preparatory activities involved with the initially published 23 reports. Utilizing the 1983-1984 survey results and information gathered during subsequent research efforts, the eight additional sites were researched and case study reports prepared. The focus of this more recent series of eight case studies, however, is on Superfund-financed or enforcement action sites, as opposed to the previous studies which focused on private- and State-led actions.

The case study reports are intended for use by EPA regional officials, state agencies, industry and commerce, and local authorities involved in selection, evaluation and design of remedial response actions. The case study reports provide the following:

- A systematic method of recording detailed results of remediation programs
- An understanding of the remediation process such that future response actions can be developed and implemented in the most technically efficient and cost-effective manner possible
- A standard of comparison during evaluation and selection of response measures at sites with similar problems
- Identification of remedial technologies that may warrant further research

- Quantification and documentation of the extent and type of remedial response actions being implemented nationwide

- Development of data to aid in cost recovery actions promulgated by the USEPA.

Section 2 of the Executive Summary discusses the site selection and case study investigation processes involved in the completion of this research project. The results obtained from the eight case study investigations are summarized in Section 3, and the remainder of the document consists of the eight detailed case study reports.

2.0 SITE SELECTION AND CASE STUDY METHODOLOGY

Initially a survey was conducted of Superfund-financed sites and enforcement sites to identify candidate case study sites. The survey, conducted by contacting regional EPA Superfund offices, identified over 30 sites where remedial responses had been partially or entirely completed. Eight sites were selected from the candidate list for case study reports. These sites are listed in Table 1. The criteria used for site selection included:

- Current status with regard to percent completion of the remedial action

- Availability, accessibility, and completeness of remedial action, cost and engineering data

- Type of remedial action technology implemented, so that a range of remedial action techniques were investigated

- Type of waste management practice, so that a wide range of technologies, commonly used in hazardous waste management, were studied

- Types of waste and contaminants present at the facility to ensure that a variety of waste stream and pollutants were included

- Hydrogeologic setting, so that a variety of settings were represented

- Enforcement sensitivity.

Once the list of Superfund and enforcement sites had been developed, an in-depth and site-specific data acquisition effort was initiated. All available background information relative to each site's environmental setting, operational history, remedial actions and Superfund involvement was collected. Two readily available sources of information were used to complete this task. The first source was site-specific information collected from public information data sources, including the following:

- USGS topographic and geologic maps, geologic and hydrologic reports, soils and climatological maps and reports

TABLE 1. SITES SELECTED FOR CASE STUDY INVESTIGATIONS

Site Name	Location
1. Bruin Lagoon	Bruin Borough, Pennsylvania
2. Denney Farm	Barry County, Missouri
3. Gulf Coast Lead	Tampa, Florida
4. Lipari Landfill	Pitman, New Jersey
5. Picillo Farm	Coventry, Rhode Island
6. Rose Park Sludge Pit	Salt Lake City, Utah
7. Tacoma Well 12A	Tacoma, Washington
8. Taylor Road Landfill	Seffner, Florida

- USEPA and state files, including site-specific data on operational history, Superfund involvement, detailed remedial action, engineering design and cost data, previously documented cost studies, and litigative case support data.

The second source of site-specific data was direct correspondence with the USEPA Superfund on-site coordinators, the facility operators, and the parties primarily responsible for designing and implementing the site remedial action. During correspondence, additional site-specific information was collected, and written or verbal approvals for site visits were obtained. Prior to any field visits, collected information was thoroughly reviewed and data gaps identified for clarification during the site visits.

A schedule for all site visits was then developed. Follow-up telephone calls were made to appropriate contacts to coordinate field visit activities and schedules. Each site visit was two days in duration, and included the following activities:

- Detailed site inspection including documentation of site layout, evidence of environmental contamination, and observation of remedial action technologies being employed

- Review of all available remedial action design drawings and existing cost information

- Detailed review of the remedial action data previously collected, including pre-remediation and monitoring activities, remedial action and treatment technologies, implementation and cost details, and remedial action design data.

All sources of information and site-specific data were carefully referenced in field logs for later documentaiton in the case study reports prepared for each site. Photographic slides or prints developed from the site visits were collected and developed to track the response history.

After every site visit, individual case study reports were prepared and forwarded to the USEPA Project Officer, Task Managers, and parties involved in implementing the remedial action for their review. The case study reports have been structured so that they provide detailed data on the remediation techniques employed; the circumstances and conditions under which they were implemented; their apparent effectiveness in correcting or controlling the problem; and their potential uses in other remedial action scenarios. The following is an outline of the typical case study report:

I. Introduction

- Background
- Synposis of Site Response

II. Site Description

- Surface Characteristics
- Hydrogeology

III. Waste Disposal History

IV. Description of Contamination

V. Planning the Site Response

- Initiation of Site Response
- Selection of Response Technology
- Extent of Site Response

VI. Design and Execution of Site Response

VII. Cost and Funding

- Source of Funding
- Selection of Contractors
- Project Cost

VIII. Performance Evaluation

IX. Bibliography

3.0 RESULTS

The eight final case study reports describe an array of remedial technologies implemented at uncontrolled hazardous waste sites. In addition to technical discussions, the case studies present available cost and funding data for each site, and describe the more important institutional issues that affected the implementation of the response programs. Table 2 summarizes the site conditions at the eight sites prior to implementation of remedial and/or response actions, the remedial technologies utilized, and the total estimated costs associated with each of the eight response programs.

TABLE 2. SUMMARY OF CASE STUDY INVESTIGATIONS

SITE	SITE CONDITIONS	SITE RESPONSE	STATUS OF REMEDIAL PROGRAM	ESTIMATED COSTS
Bruin Lagoon, Bruin Borough, Pennsylvania	Earthen-diked lagoon constructed in 1930's and used as a repository for oil production wastes, waste motor oil re-refining residues, coal fines and fly ash; began to draw public attention following a 3,000-gallon sludge spill into Bear Creek which lies adjacent to site.	• Lagoon embankment improvements • Construction of concrete retaining wall along Bear Creek • Tank demolition, removal and offsite disposal • Removal and offsite disposal of liquid supernatant contained in lagoon • Sludge stabilization • Installation of venting system for acidic gas	I	$1.76 million
Denney Farm, Barry County, Missouri	Estimated 80-90 drums of wastes containing TCDD or dioxin discarded in a trench on property known as Denney Farm.	• Excavation of waste materials • Placement of soils without visible contamination in microbiological degradation basins (MDBs) • On-site storage of drummed wastes (solid waste and visibly contaminated soils) • Trench backfilling and capping • On-site incineration for ultimate destruction and disposal of wastes currently under investigation	I	N/A

(continued)

I - Incomplete at the time of case study preparation
C - Complete at the time of case study preparation
N/A - Not available at the time of case study preparation

TABLE 2. (continued)

SITE	SITE CONDITIONS	SITE RESPONSE	STATUS OF REMEDIAL PROGRAM	ESTIMATED COSTS
Gulf Coast Lead, Tampa, Florida	Contaminated rinsewater and battery casings from lead recovery operations at the GCL smelting facility were dumped in unlined surface depression on company property. Soil and shallow groundwater became contaminated with sulfuric acid and heavy metals, thus presenting a threat to an underlying aquifer.	• Implementation of groundwater monitoring program • Removed battery casings from surface depression • Capping of site • Installation of retention basin to collect and recycle contaminated surface runoff from site • Installation of underdrain system to collect rainwater runoff from uncontaminated areas for discharge to Tampa storm drains • Installed a groundwater treatment system • Subsurface acid reaction barrier to intercept/neutralize contaminated groundwater that migrated off site was under study at time of this writing	C	$700,000
Lipari Landfill, Pitman, New Jersey	Seven-acre area used for disposal of industrial and domestic wastes including solvents, formaldehyde, paints, phenol and amine wastes; concern focused on contamination of two nearby streams, a lake and two aquifers.	• Construction of a soil-bentonite slurry trench cutoff wall around a 16-acre area which included the 7-acre landfill • Installation of synthetic membrane cap over the 16-acre site • Installation of passive gas collection and venting system • Completion of groundwater treatability study and design of a collection and treatment system	I	$2.5 million

(continued)

I - Incomplete at the time of case study preparation
C - Complete at the time of case study preparation
N/A - Not available at the time of case study preparation

TABLE 2. (continued)

SITE	SITE CONDITIONS	SITE RESPONSE	STATUS OF REMEDIAL PROGRAM	ESTIMATED COSTS
Picillo Farm, Coventry, Rhode Island	A 7.5-acre area used as a hazardous waste disposal site during the 1970's; over 10,000 drums were found containing such wastes as industrial solvents and oils, pesticides, PCBs, paint wastes, and explosives were buried in 4 trenches on site; leachate migrated through soil into nearby swamp, contaminating groundwater, surface water and soil in vicinity.	• Drum removal and off-site disposal • Ground and surface water monitoring of swamp and contaminated groundwater plume • Detonation of unidentified materials • Landfarming of contaminated soils • Completion of a feasibility study on groundwater recovery, treatment and discharge	I	$4.96 million
Rose Park Sludge Pit, Salt Lake City, Utah	Six-acre disposal site located in a public park; between 1920 and 1957 acid sludges were discarded in unlined pits and covered with lime and soil; the site was covered with a soil cap in 1960; the site again received attention in 1976 when construction activities induced the extrusion of sludge at the surface; low concentrations of contaminants were found in groundwater in immediate area but had not migrated appreciably.	• Installation of groundwater monitoring wells around sludge pit • Construction of a soil-bentonite slurry trench cutoff wall around the site • Construction of a sand filter, filter fabric and clay cap system • Installation of fence around perimeter of site	C	$1.2 million

(continued)

I - Incomplete at the time of case study preparation
C - Complete at the time of case study preparation
N/A - Not available at the time of case study preparation

TABLE 2. (continued)

SITE	SITE CONDITIONS	SITE RESPONSE	STATUS OF REMEDIAL PROGRAM	ESTIMATED COSTS
Tacoma Well 12A, Tacoma, Washington	Well 12A, the northern most of 13 wells in a well field in South Tacoma Channel, was taken off line after chlorinated organic solvents detected in groundwater sample; the source was identified as being north of the well field; the spreading of contaminants to other wells after 12A was taken out of service indicated that further contamination of the well field could be prevented if Well 12A remained operational to act as an intercepter or barrier.	• Installation of an air-stripping system at Well 12A to remove volatile organics (considered an interim remedial measure) • Completion of studies to identify contaminant source, and design and implement a permanent solution	C	$948,133
Taylor Road Landfill, Seffner, Florida	A 42.5-acre sanitary landfill in which unknown quantities of hazardous wastes including solvents, paint thinners, insecticides, herbicides, fungicides and sludges were deposited; groundwater samples collected at the site found to contain VOCs and metals in concentrations above acceptable safe drinking water standards.	• Upgrading of surface cap • Channelization of surface drainage along eastern and southern site boundaries • Installation of a methane gas collection and control system • Development of long-term groundwater and methane gas monitoring program	C	$3.56 million

I - Incomplete at the time of case study preparation
C - Complete at the time of case study preparation
N/A - Not available at the time of case study preparation

BRUIN LAGOON

BRUIN BOROUGH, PENNSYLVANIA

INTRODUCTION

NCP Reference

Bruin Lagoon, one of Pennsylvania's 39 priority Superfund sites, is an abandoned industrial waste lagoon located in Bruin Borough, Butler County, Pennsylvania (Figure 1). The 4-acre (1.6-ha) site consists of a 1-acre (0.8-ha), earthen diked lagoon, two additional closed lagoons, an effluent pond, and close to 40 abandoned tanks.

300.68(e)(2)(i)(B) amount and form of substances present

Bruin Lagoon was constructed in the late 1930's for the disposal of white oil production wastes and continued to serve as a repository for residue from waste motor oil re-refining, coal fines, and fly ash for the next 40 years. An estimated 35,000 cubic yards (26,760 m^3) of acid sludge, 450,000 gallons (1.7×10^6 l) of liquid supernatant, 40,000 cubic feet (3,716 m^3) of contaminated soil, and 15,000 cubic yards (11,468 m^3) of contaminated dike soil was discovered within and around the site during field investigations and the planned remedial response. When, in 1981, it was discovered that the lagoon contents were threatening to overflow the berms amd were leaching through the base of the dike into area surface waters, U.S. EPA Region III personnel initiated an emergency response. Two years later, in September 1983, a long-term remedial action program to clean up the site began. This program was to have included supernatant removal and disposal, off-site disposal of tanks, sludge stabilization and on-site containment, and final capping and grading. In May 1984, however, the program was interrupted when lagoon workers encountered a crust layer and hydrogen sulfide gas within the lagoon sludge. An emergency response team was brought on-site in July 1984 and remained on-site for monitoring purposes through September 1984. In late September, the remedial contract and contractor were officially terminated because EPA decided that it was necessary to reevaluate site conditions and redesign any further remedial work at the site. Remedial investigation and feasibility study (RI/FS) activities under a new remedial contract commenced

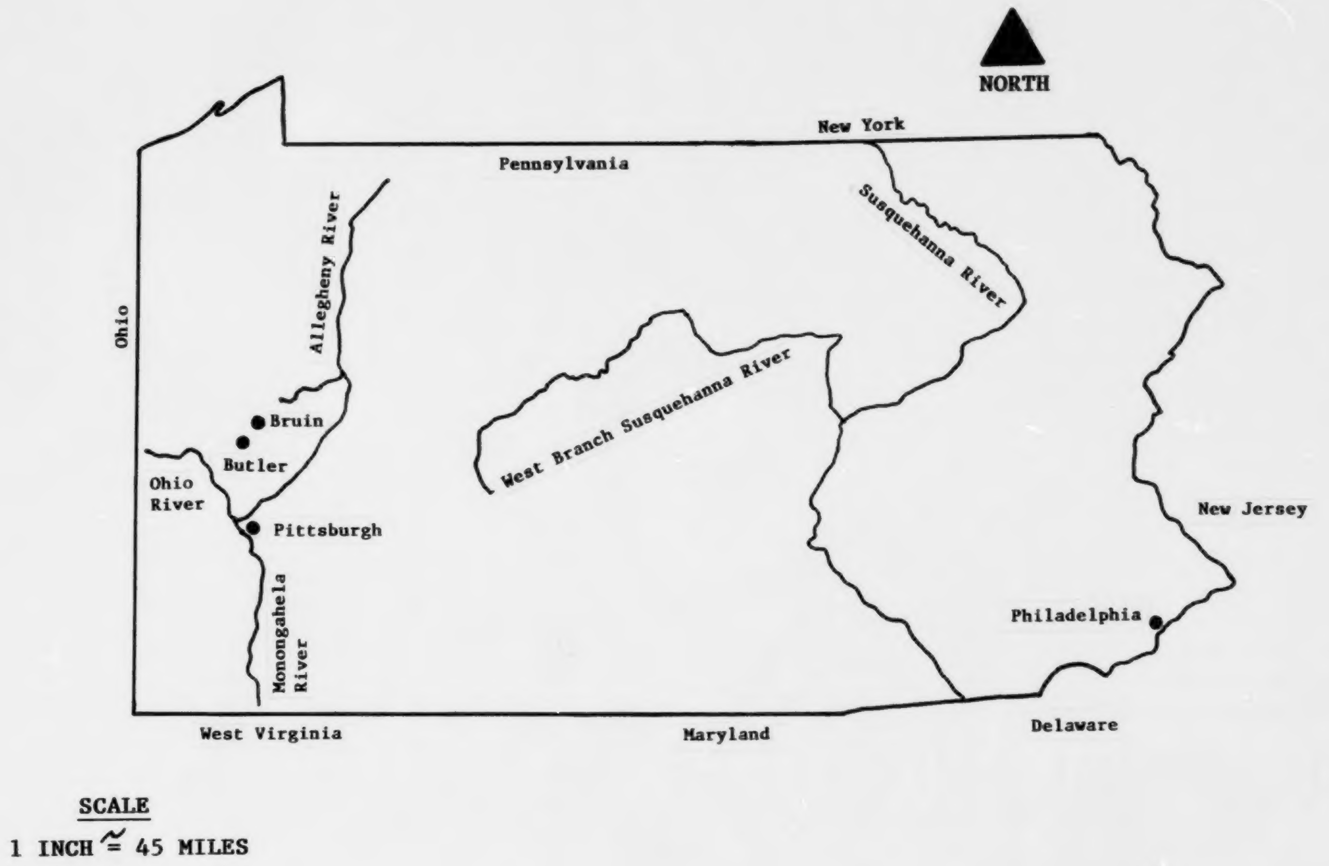


Figure 1. Map of Pennsylvania Showing Location the Bruin Lagoon Site, Bruin Borough, Butler County, Pennsylvania

during the winter of 1985. At the time of this writing, the second emergency response (July 1984) was still underway; therefore, this report focuses on the remedial actions completed before work was halted due to unexpected site conditions.

Background

The open lagoon and effluent pond are located on the west bank of the South Branch of Bear Creek, 7 miles (11.3 km) upstream of the confluence of the creek and the Allegheny River in an industrialized area. The Bruin Lagoon began to receive attention following a sludge spill that entered the surface waters of Bear Creek in August 1968. At this time, the site was owned and operated by American International Refining Corporation. The site was bought in 1974 by the present owner, A.H.-R.S. Coal Company, a coal washing operation, who had full knowledge of the lagoon hazard.

In 1978, the Pennsylvania Department of Environmental Resources (PADER) filed a complaint in equity against the company, marking the first in a series of legal actions taken by the State for abatement of the lagoon hazard. In addition to surface water contamination, another main focus of concern was on the potential for groundwater contamination. Groundwater contamination in the vicinity of the lagoon was confirmed by investigations conducted by EPA in 1981. A single series of surface water samples were also collected, identifying contamination of Bear Creek; however, because of upstream discharges from other facilities, the source of contaminants could not be confirmed. During the remedial investigation in 1981, air samples exhibited only background contamination levels.

300.62(a)
state role

300.65(b)(5)
sampling

After a detailed dike stability study was completed in 1982, it was concluded that the lagoon contents had adversely affected the stability of the dike and that there was a definite possibility of the dike's failure.

Synopsis of Site Response

A. Emergency

In September 1981, EPA's Environmental Emergency Branch undertook an immediate removal action at the Bruin Lagoon site. Interim measures taken during the emergency response included controlling site access by installing gates and stepping up security, improving the dike by adding riprap, raising the berm height to prevent overflow, and constructing a discharge line to the adjacent effluent pond with an overflow outlet from the pond to the

300.65(a)
immediate
removal

stream. Prior to the commencement of the emergency site work, air monitoring was conducted to determine whether the site was causing hazardous air emissions. Air sampling results indicated that there was no danger to workmen on-site and respiratory equipment was unnecessary for the activities that followed.

B. Remedial

Under the planned long-term response program, EPA's contractor began site preparation activities in September 1983. After the U.S. Army Corps of Engineers' consultant reviewed the contractor's work plans in October, excavation in the lagoon and dismantling of the tanks began. By the end of 1983, approximately 500,000 gallons (1.8 x 10^6 l) of liquid supernatant (50,000 gallons more than was originally estimated) had been removed from the lagoon for off-site disposal and a trial sludge stabilization program had commenced.

300.68(e)(2)
source control
remedial action

In early 1984, following the completion of improvements on the northern slope of the lagoon embankment, construction of a concrete retaining wall along Bear Creek began. Tank testing was completed in February, and by March, 90 feet (27 m) of the retaining wall had been emplaced and all tank demolition was completed by the first week in April. The majority of these items had also been disposed by this time, although drums encountered after the project had begun were not removed until later. Also, in April, EPA's contractor formed a shale dike to isolate an area in the lagoon for backfilling stabilized material. By this time, a final total of over 1,000,000 gallons (3,785,410 l) of contaminated aqueous liquid had been removed from the lagoon and effluent pond and transported to an approved treatment facility in Cleveland, Ohio.

On May 4, 1984, workmen disturbed a crust layer and released an acidic gas while digging in the lower portion of the lagoon sump. Subsequent test results, revealing the composition of the crust to be aluminum sulfate and used oil, and the underlying material to be sulfuric acid and hydrogen sulfide, prompted EPA and the State to change the project to emergency status. In early July 1984, Region III brought in a separate, specially trained emergency response team to handle the highly toxic, newly discovered waste. The original remedial contract and associated contractors had been terminated. A new remedial contract was let for an RI/FS in the fall of 1985. Due to concerns regarding dust, vapor, and odor from the stabilization process, EPA and the Corps of

Engineers monitored off-site air to ensure that the site posed no additional threats to the environment or to public health.

SITE DESCRIPTION

Bruin Lagoon is located at latitude 41°3'5" and longitude 79°43'30", along the western bank of the South Branch of Bear Creek in Bruin Borough, Butler County, Pennsylvania. Bear Creek is a tributary to the Allegheny River, which is located about 7 miles (11 km) downstream. The site is bounded by Route 268 to the west, and Bear Creek and a spur of the Baltimore and Ohio Railroad to the east. Residences in the Borough of Bruin also adjoin the site (Figure 2).

Surface Characteristics

The Bruin Lagoon site is located in the west-central part of the Appalachian Plateau province. The area is characterized by rounded hills and steep sided valleys. Flat, upland surfaces are uncommon. Elevations range between 1,100 and 1,400 feet (355-426 m) above mean sea level (msl).

The site lies within the 100-year floodplain of the South Branch of Bear Creek. The lagoon's eastern dike is directly adjacent to the creek's west bank.

The South Branch of Bear Creek is a relatively small stream with a drainage area of approximately 15 square miles (39 km^2). The creek flows through a fairly steep-sided valley; however, it has a very low gradient, resulting in a slow flow. A one-time instantaneous measure of high and low flows recorded 50 and 28 cubic feet per second (4.6 and 2.6 cms), respectively, and it is estimated that the creek can experience extreme low flows of 10 cfs (0.93 cms) (Weston 1982a). The steep valley walls/low gradient/slow flow characteristics of the creek can lead to extensive overbank flooding during severe storm events.

The soils on-site have been highly disturbed by construction and operation activities over the years. During the construction of the dike that surrounds the lagoon, the silty clay soil overburden was removed from the western part of the site and was used as dike material. Bedrock is now exposed in this area of the site, as well as along the stream bed. Native soil profiles are lacking; however, it is presumed that they were relatively thin because the site is located in a steep-sided valley

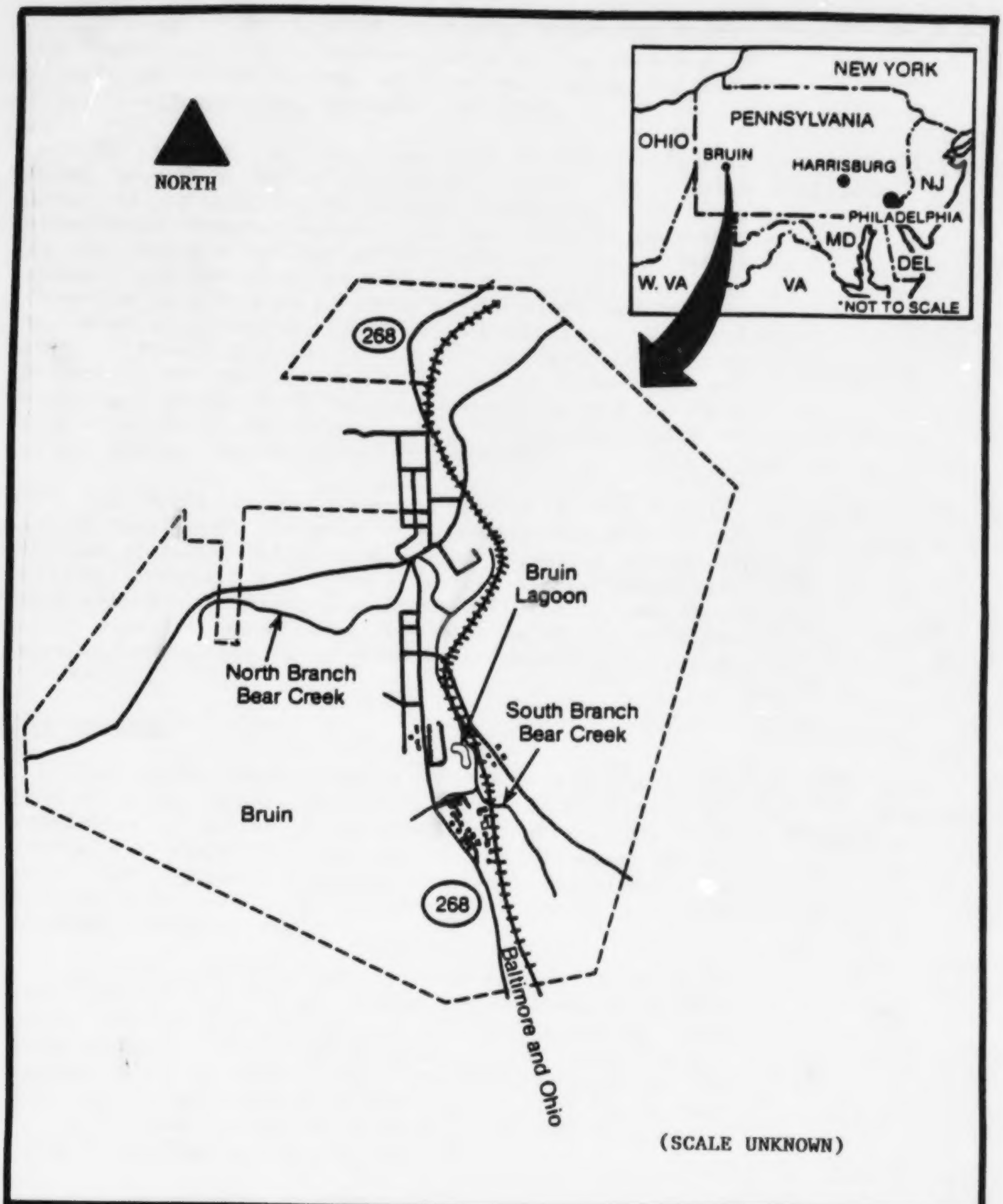


Figure 2. Site Location Map, Bruin Lagoon, Butler County, Pennsylvania

Source: Weston 1982a

predominated by outcrops of horizontal undeformed shales and sandstones. Soil analyses indicate the presence of significant concentrations of aluminum, barium, calcium, iron, lead, magnesium, manganese, and zinc.

The climate in the site area is characterized as being generally humid continental, which, on a local level, is affected by the rugged topography. The area experiences distinct seasons that are slightly moderated by the nearness of the Great Lakes and, to a lesser extent, the Atlantic seaboard. The prevailing wind direction in this area is westerly, and winds pass through the area at an average speed of 9.4 miles per hour (15 kmh). Precipitation is fairly evenly distributed throughout the year and averages about 40 inches (102 cm) annually. Temperatures usually range from -5°F to 100°F (-20°C to 38°C) during the course of the year, with an annual average temperature of 50.9°F (10°C).

300.68(3)(2)(i)(E)
climate

The Bruin Lagoon site is located in the Petrolia Valley immediately adjacent to a residential area in the Borough of Bruin, which has a present estimated population of 740. Petrolia Valley is a narrow, highly industrialized valley supporting coal mines, oil fields, and three major chemical companies. The industry in the area has contributed heavily to existing environmental problems in the valley.

300.68(e)(2)(i)(A)
population at risk

Hydrogeology

The Bruin Lagoon site is located in a stream valley typical of the region, sharply cut into the subhorizontal sandstones and shales of the Allegheny Plateau. The sandstones and shales are members of the Allegheny Group, which also includes limestone and coal deposits. The Clarion coal seam, the predominate mineable coal, is abundant throughout the area.

300.68(e)(2)(i)(D)
hydrogeological
factors

As reflected in boring logs, the surface of the sandstone bedrock beneath the lagoon slopes downward to Bear Creek, and the lagoon deepens to the east toward the creek where the soil dike is approximately 22 feet high (6.7 m). Figures 3 and 4 present cross-sectional diagrams of the open and closed portions of the lagoon. The top of bedrock elevations for the Bruin Lagoon site have been mapped using boring logs and are shown in Figure 5.

The groundwater system flowing beneath the lagoon area is a semicontinuous aquifer composed of two flow regimes. The upper regime is identified as "shallow" groundwater, or the perched water table, and flows above and along the bedrock surface. The "deep" groundwater

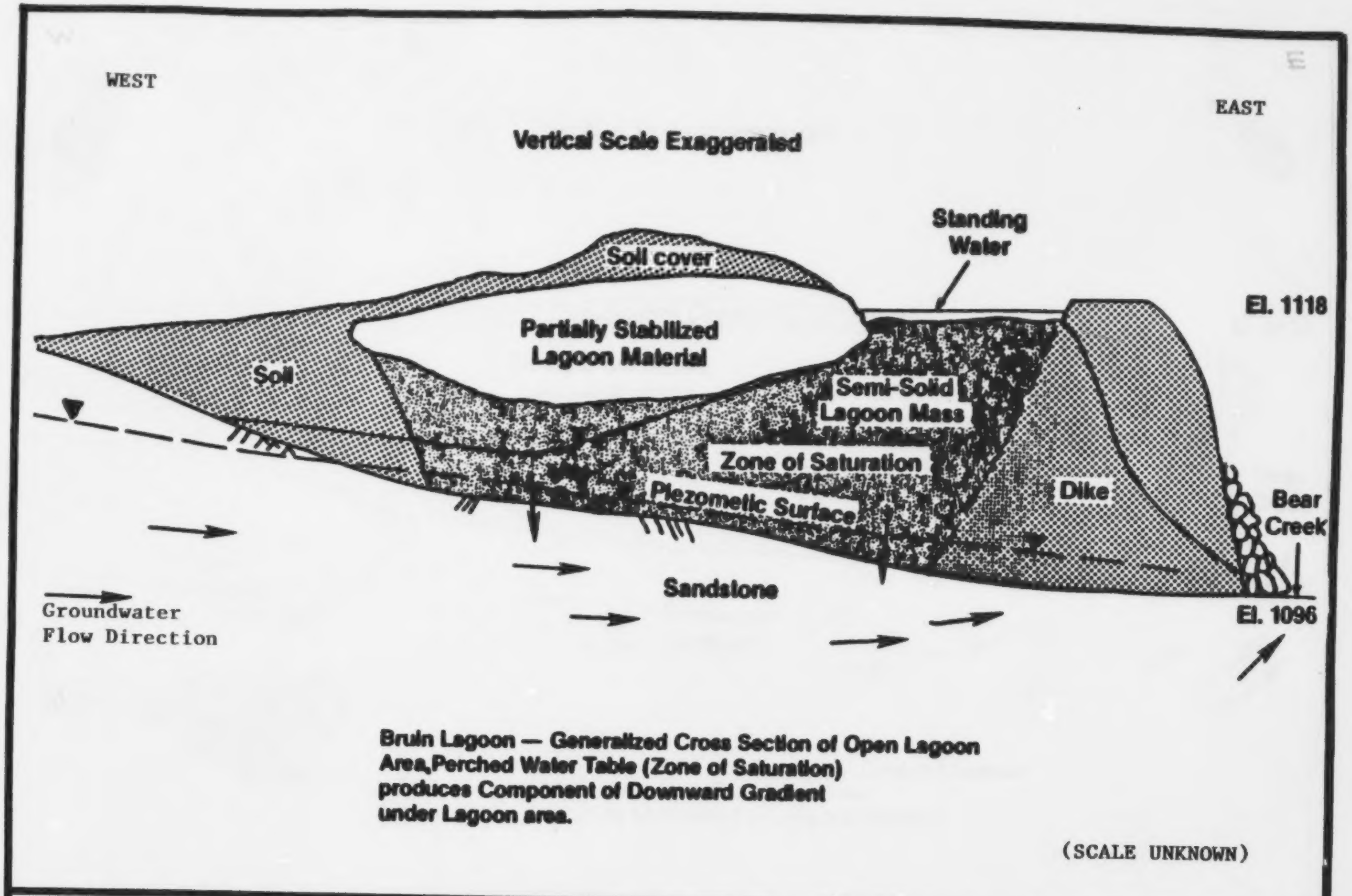
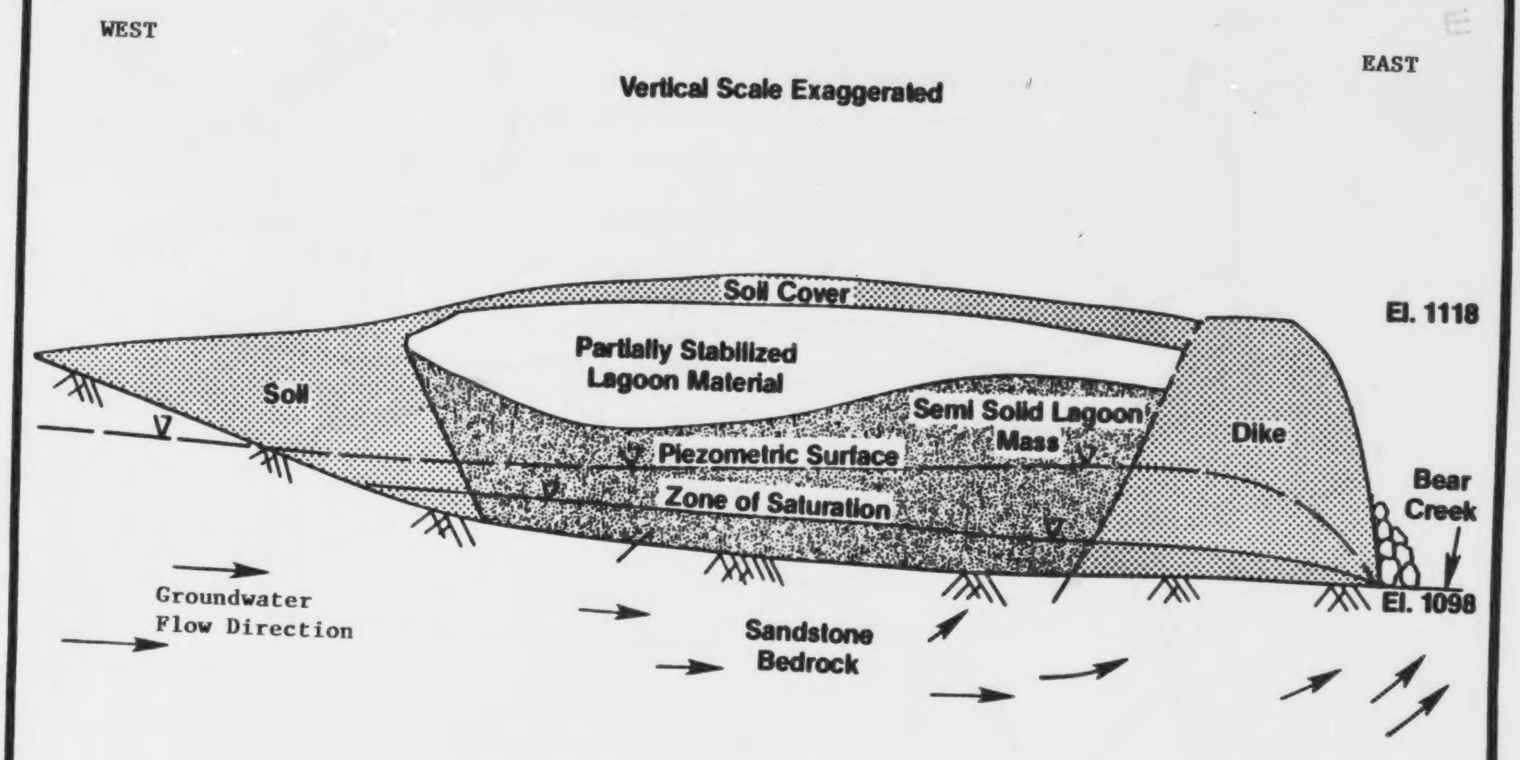

WEST
EAST
Vertical Scale Exaggerated
Standing Water
Soil cover
Partially Stabilized Lagoon Material
El. 1118
Soil
Semi-Solid Lagoon Mass
Zone of Saturation
Piezometric Surface
Dike
Bear Creek
Sandstone
El. 1096
Groundwater Flow Direction
Bruin Lagoon — Generalized Cross Section of Open Lagoon Area,Perched Water Table (Zone of Saturation) produces Component of Downward Gradient under Lagoon area.
(SCALE UNKNOWN)

Figure 3. East-West Cross Section Through Open Lagoon Area, Bruin Lagoon, Pennsylvania

Source: Weston 1982a



Bruin Lagoon — Generalized Cross Section of Covered Lagoon Area. Piezometric Surface in rock is higher than Water Table, producing component of Upward Gradient.

(SCALE UNKNOWN)

Figure 4. East-West Cross Section Through Closed Lagoon Area, Bruin Lagoon, Pennsylvania

Source: Weston 1982a

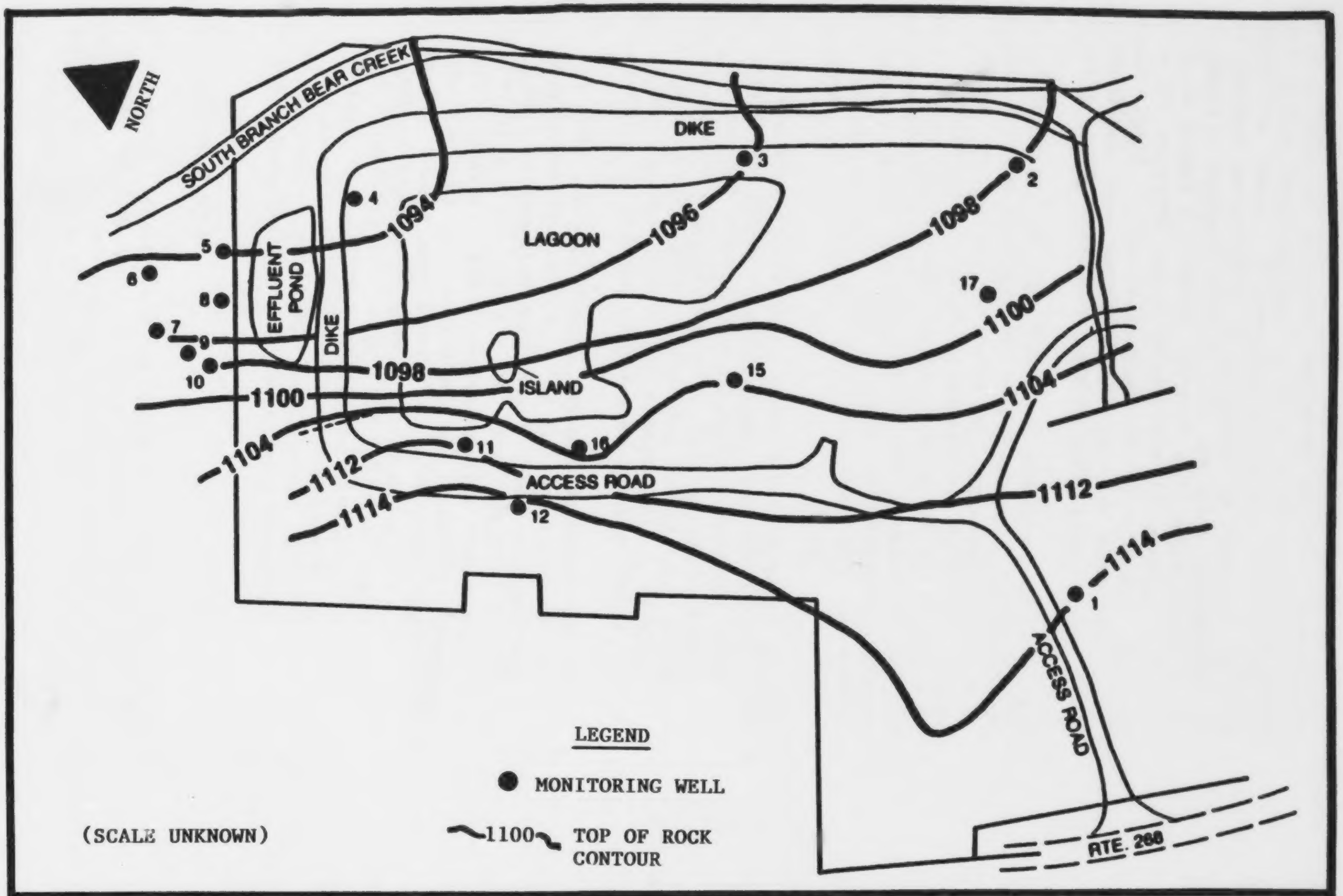


Figure 5. Top of Bedrock Contours, Bruin Lagoon, Pennsylvania
(Contour Interval Varies in Feet)

Source: Weston 1982a

flows within the fractured sandstone bedrock. Groundwater flow within both regimes is in a northeastern direction toward the creek. A groundwater surface contour map for the perched water table is presented in Figure 6, and the piezometric surface contours of the deep groundwater is shown in Figure 7. These contours were constructed on the basis of observed water elevations in on-site wells (Weston 1982). The direction of groundwater flow is downgradient and perpendicular to the contours, i.e., easterly to northeasterly towards Bear Creek.

Groundwater in the fractured sandstone is recharged by infiltration through the valley slopes. Infiltration at higher elevations produces an increased groundwater head, resulting in artesian conditions near the valley floor where springs are common. As shown in Figure 4 in the covered section of the lagoon, the piezometric surface in bedrock wells was higher than the bedrock surface. This indicates that groundwater flow has an upward component.

In the open lagoon area, where standing water existed and there was steady infiltration, the additional load upon the perched water table produced a downward vertical flow component (see Figure 3). This mounding effect is characteristic of lagoons containing liquid, and the downward flow component that results represents a pathway for contamination in bedrock groundwater (Weston 1982a).

The rate of groundwater movement through the silty clay overburden is controlled by the permeability of the soil. This recompacted soil has a field permeability on the order of 3×10^{-3} to 3×10^{-2} feet/day (9.1×10^{-4} to 9.1×10^{-3} m/day). The groundwater flow rate within the sandstone bedrock is controlled by secondary porosity, essentially joints and fractures. Recovery in on-site wells yielded average permeability values of 1.9×10^{-2} to 1.3×10^{-1} feet/day (5.7×10^{-3} to 3.9×10^{-2} m/day). It is important to note that these are average permeabilities. Groundwater flow within the sandstone is primarily through secondary openings, i.e., joints and fractures, while the unfractured rock is essentially impervious.

WASTE DISPOSAL HISTORY

The open lagoon was originally constructed in October 1937 by John Tack of Butler County, Pennsylvania. At that time, the open lagoon dimensions measured approximately 80 feet (24.4 m) by 300 feet (91.4 m). The lagoon was more or less rectangular in shape, with the north end approximately 15 inches (38 cm) shallower than the south

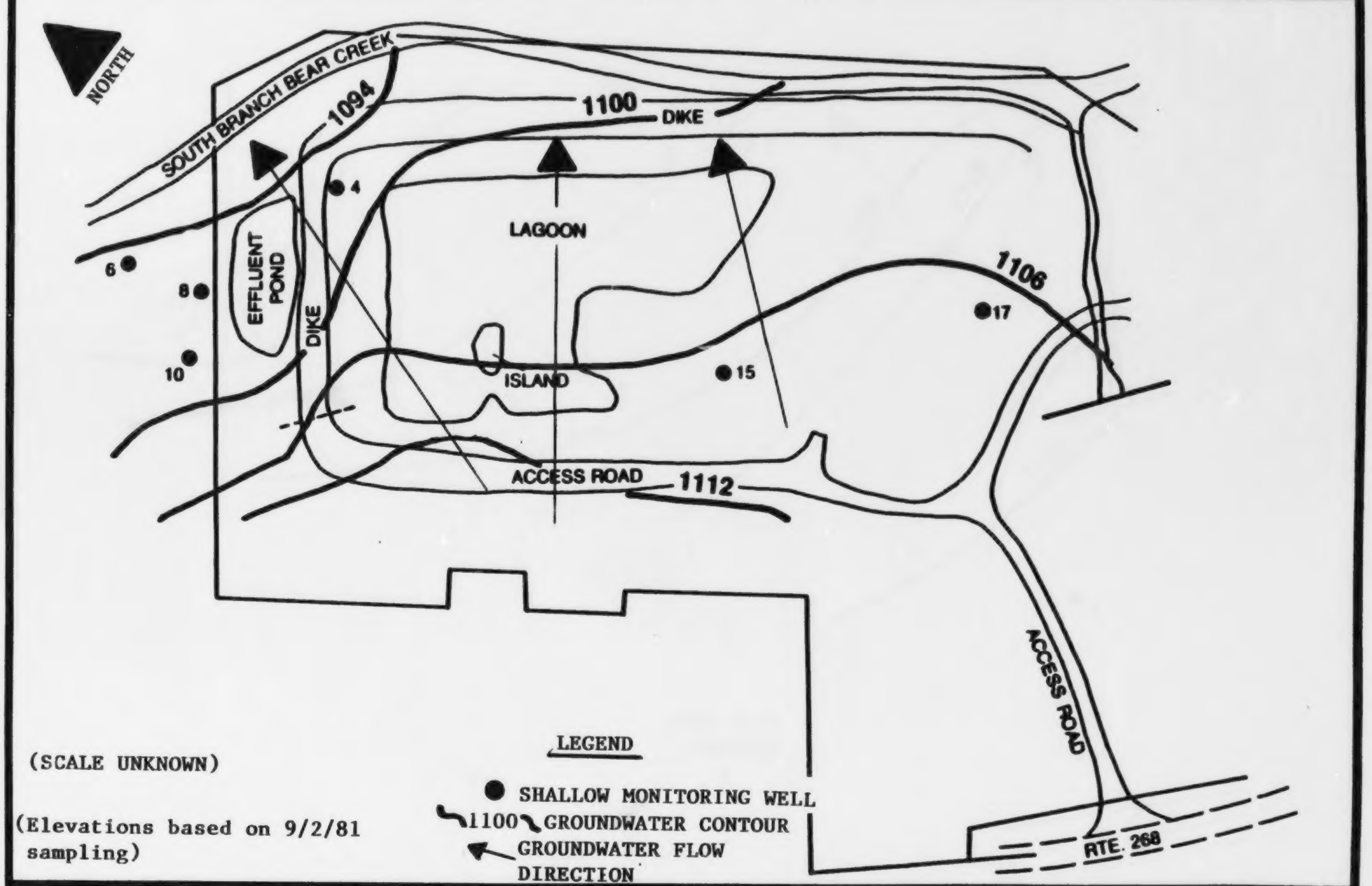
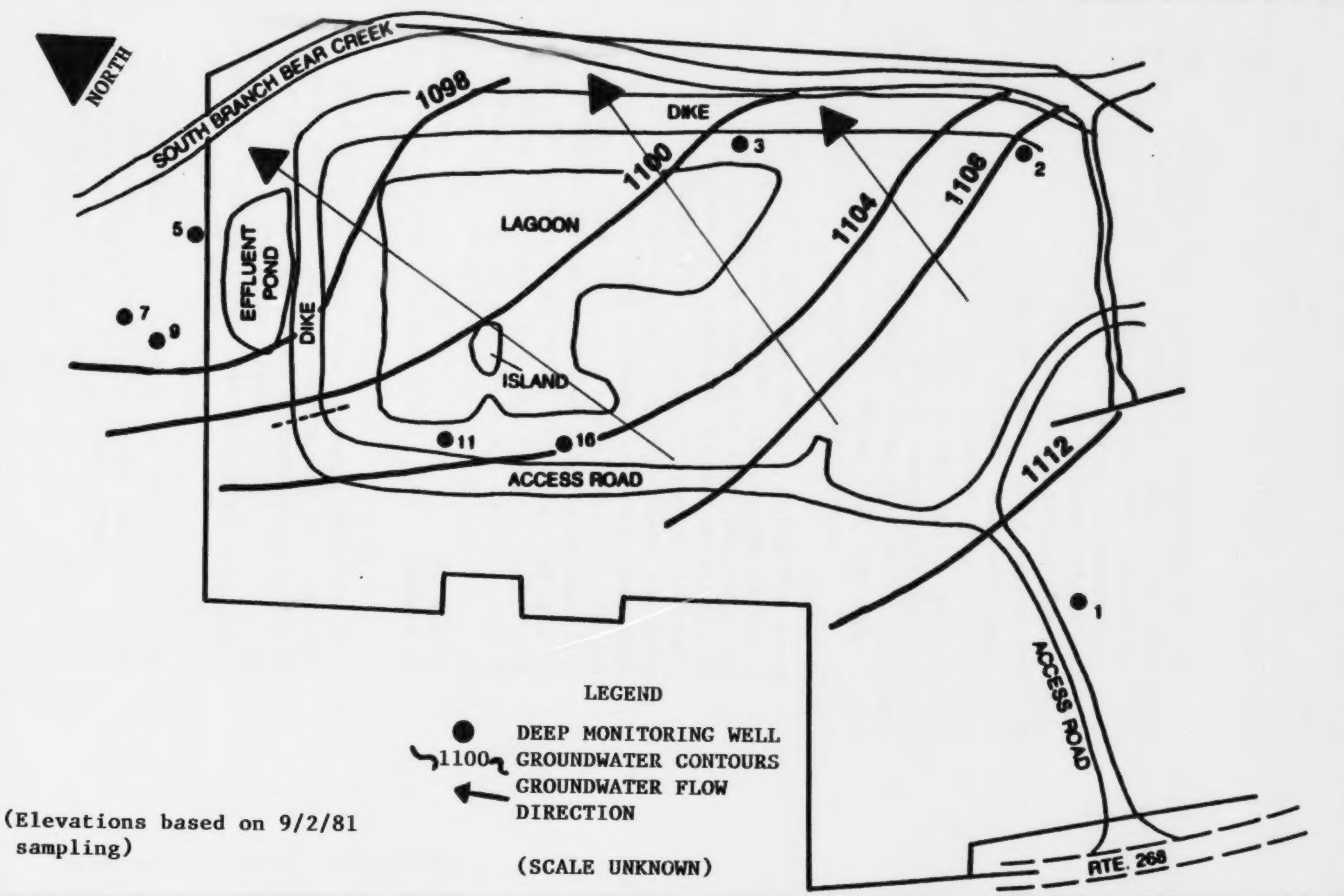


Figure 6. Perched Ground Water Contours and Flow Direction, Bruin Lagoon, Pennsylvania

Source: Weston 1982a



(Elevations based on 9/2/81
sampling)

Figure 7. Deep Ground Water Contours and Flow Direction, Bruin Lagoon, Pennsylvania

Source: Weston 1982a

end. According to an EPA photographic interpretation report, two unequal sized (dimensions unknown) lagoons (referred to here as the open and closed lagoons) were present along the bank of the South Branch of Bear Creek in 1938.

300.68(e)(2)(i)(B)
amount and form
of substances
present

The lagoon was utilized as a repository for various wastes and their residues from the time of its construction to the mid-1970's. These included wastes from the production of white oils and waxes, diatomaceous earth used as a filtering agent in a used motor oil re-refining process, and coal fines from a coal cleaning plant. More specifically, these wastes included: acid sludge from the manufacture of white oils; bottoms and settlings from crude oil storage tanks; spent bauxite from the filters used on white oil and petrolatums; bone powder and charcoal from filter operations; spent alkali, sodium hydroxide, and sodium carbonate from acid neutralization; re-refined oil; sludge; boiler house coal and ashes; and lime from attempts to neutralize the lagoon.

There are only a few reports indicating the amount of these wastes disposed of at the site. One report indicated that, during the period from 1937 to 1944, approximately 180,000 gallons (680,000 l) of white oil sludge and up to 140 tons (127 metric tons) of bauxite were deposited in the lagoon from the production of white oil at the Ultra-Penn Refining Company. During this process, the oil was acidified with an average ratio of 450 gallons (1700 l) of 20 percent sulphuric acid for each 10,000-gallon (38,000 l) batch of oil. The acidified oil from a steel pickling bath was then neutralized with 50 baume sodium hydroxide to a pH of 7.0, washed with ethyl alcohol, and filtered with bauxite in a 5-ton (4.5 metric ton) and 7-ton (6.3 metric ton) filter. Afterwards, the bauxite was recycled up to eight times before being disposed of in the lagoon.

By October 1950, there was evidence that two distinct lagoon areas existed. In the 1950's and 1960's, the size of what is designated here as the open lagoon, increased to the south to 18,000 square feet (1,700 m^2). The second lagoon, in the western section of the site, occupied about 20,000 square feet (1,800 m^2).

County records have no listing of owners prior to 1962, whereafter the site changed hands four times before its acquisition in 1974 by the present owner. The first record of the Bruin Lagoon site was on April 12, 1962 with a transfer of 25 acres (10.2 ha) from Ultra-Penn to Borne Chemical Company of New Jersey. Another source listing Borne as Borne-Scrymser Company, a producer of synthetic soaps, stated that the company apparently made no use of the lagoon. Two and one half years later, the site was purchased by Bruin Oil Company for re-refining used motor oil collected from service stations in western Pennsylvania. Bruin Oil Company later reported to the State that it had put 150,000 gallons (570,000 l) of diatomaceous earth (used as a filtering agent) into the lagoons.

On February 2, 1968, American International Refining Company (AIRC) purchased the site property. AIRC engaged in buying the sludge left over from the production of household detergent and, after extracting the oil soluble detergent, sold the remaining sludge to Allied Chemical Company.

In August 1968, AIRC contracted out to an earthmoving firm to shore up the dikes and to backfill the lagoon. In October, during the ninth week of reclaiming operations, the widened dike began to crumble and the contents of the lagoon were displaced. Three thousand gallons (11,000 l) of waste discharged into the South Branch of Bear Creek. In an effort to prevent another discharge incident, AIRC began hauling its waste off-site in tank trucks instead of using the lagoons.

A.H.-R.S. Coal Company bought a 20.95-acre (8.1-ha) parcel from Bruin Oil Company in September 1974. In June 1979, A.H.-R.S. sold 6.8 acres (2.8 ha) of their 20.95 acres (8.1 ha) to JTC Industries of Pittsburgh. However, the lagoon was situated on the 14.15 acres (5.7 ha) still owned by A.H.-R.S.

By May 1972, enough excavation and fill activity had occurred to noticeably alter the appearance from the lagoon's original shape of 1938. Figure 8 presents past and present lagoon configurations.

Before cleanup work began, the open lagoon contained approximately 35,000 cubic yards (26,759 m^3) of asphaltic sludge and 500,000 gallons (1.8 x 10^6 l) of liquid supernatant. Moreover, there were 40,000 cubic yards (30,000 m^3) of other contaminated lagoon material (a soil and sludge mix), 13,000 cubic yards (10,000 m^3) of contaminated dike soil, and 2,000 cubic yards (1,500 m^3) of contaminated surface soil from the scrap tankage area. The effluent pond held some 30,000 gallons (110,000 l) of the total volume of supernatant.

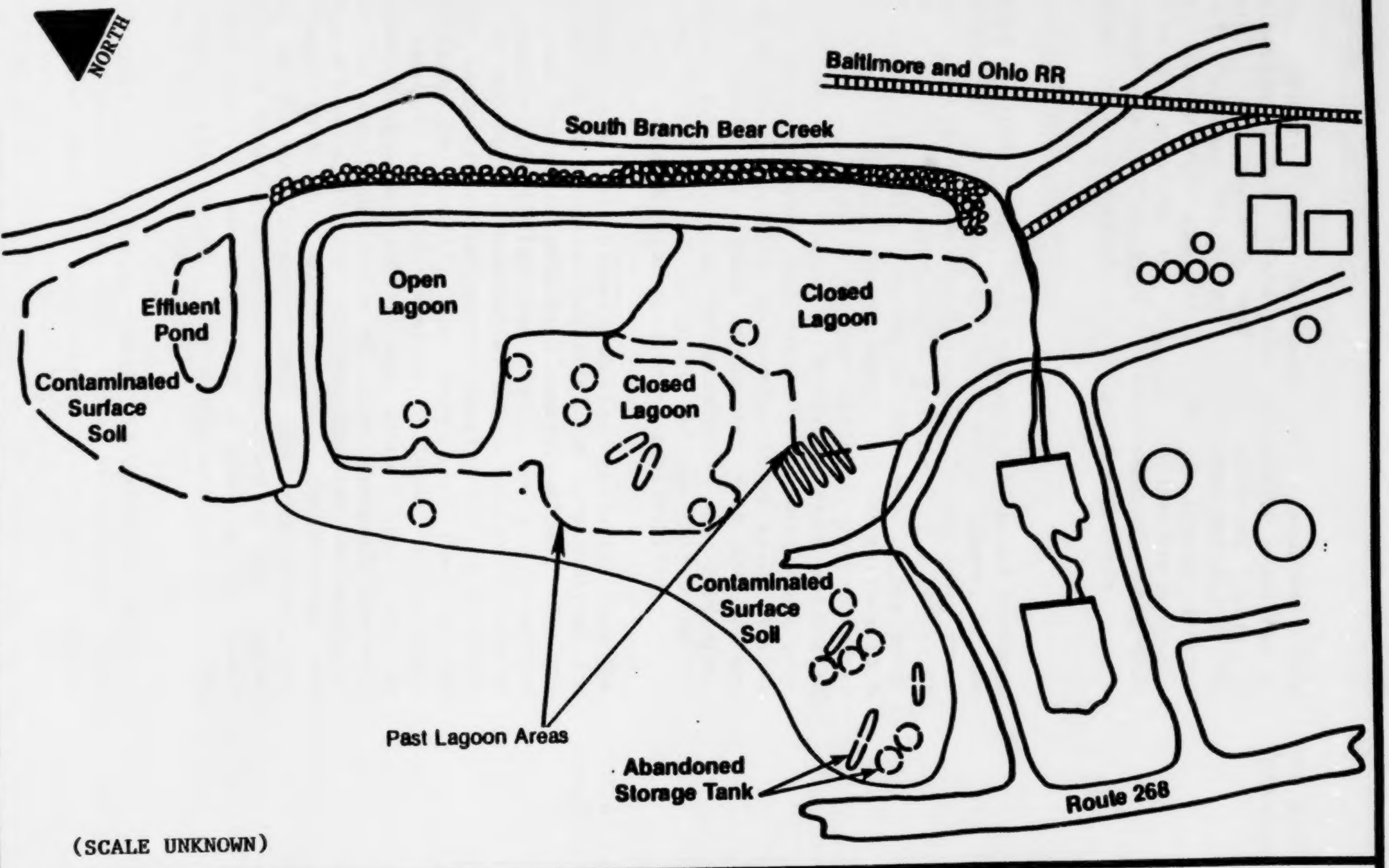


Figure 8. Past and Present Conditions at Bruin Lagoon, Pennsylvania

Source: Weston 1982a

DESCRIPTION OF CONTAMINATION

300.63(a)(2)
investigation

In January 1982, following an extensive field investigation effort, EPA's zone contractor submitted an analysis of environmental conditions at Bruin Lagoon as part of the Remedial Investigation/Feasibility Study (RI/FS) report for the site. The following section discusses the sampling and analyses results for both the waste materials on-site, and the environmental media that are potentially affected by contaminated migration.

Lagoon Sludge and Supernatant

From the results of field investigations and findings of the various studies conducted at Bruin Lagoon, it was originally estimated that approximately 35,000 cubic yards (27,000 m^3) of sludge and 300,000 gallons (1.1 x 10^6 l) of liquid supernatant were present in the open lagoon area. In addition, there were an estimated 146,000 gallons (5.5 x 10^5 l) of supernatant in the effluent pond directly north of the open lagoon. However, this estimated quantity of supernatant was exceeded as later work progressed at the site. Due to precipitation collecting in the open lagoon and coming in contact with the sludge, additional acidic liquid (supernatant) was generated, resulting in a total of 1,000,000 gallons (3.8 x 10^6 l) having to be removed prior to sludge stabilization.

300.65(b)(5)
sampling

Sludge and supernatant samples collected from the lagoon during the remedial investigation were analyzed for organic and inorganic pollutant concentrations. Analytical results identified the sludge as a mixture of inorganic and organic compounds. High concentrations of priority inorganic contaminants, ranging in the hundreds to thousands ppm (mg/l), that were identified in the sludge samples included aluminum, calcium, iron, lead, magnesium, manganese, sodium, and zinc. There are two reasons for the high levels of these inorganic cations: (1) they are released due to the high acidic nature of the sludge (2-3 pH); and (2) these constituents are present in the area's native soil and rock formations. The priority organic compounds identified in the sludge, including PCB-1260 at less than 1 ppb (ug/l), bis(2 ethylhexyl) phthalate, and methylene chloride at concentrations below 1 ppm (mg/l).

Although concentration levels of priority organics were significantly lower than those of priority inorganics, there were high concentrations of total organic carbon (TOC) and volatile solids (VS). TOC concentrations ranged from 74,000 ppm (mg/kg) to 160,000 ppm (mg/kg). VS concentrations ranged from 31 percent to 46 percent.

A critical environmental problem posed by the sludge at the Bruin Lagoon site is reflected in the high concentrations of surface-active detergents or methylene blue active substances (MBAS) identified in the sludge samples. These substances include both alkyl benzene sulfonate compounds and linear alkyl sulfonate compounds, which have been known to cause severe river foaming incidents and river pollution. The MBAS concentrations in the sludge samples ranged from 930 ppm (mg/kg) to 41,300 ppm (mg/kg).

Analyses results for supernatant liquid samples identified only inorganic constituents; in addition, the concentration levels were on the average 10 times lower than the levels detected in the sludge samples. MBAS concentrations were also significantly lower, ranging from 1,920 ppm (mg/l) to 3,160 ppm (mg/l).

Tank Contents

As part of the Bruin Lagoon RI/FS, the contents of five abandoned tanks located on-site were sampled and analyzed. The tanks were in varying states of decay and none were found to contain any significant quantities of liquid or sludge. However, tank sampling indicated the presence of two PCB compounds, PCB-1242 and PCB-1260, which were the same as those identified within the lagoon sludge. Concentrations were less than 10 ppm (mg/kg). Dioxins in the form of 2,3,7,8-tetrachlorodibenzo-p-dioxin were found at levels less than 1 ppm (mg/kg). Dioxins were not identified in any of the soil, lagoon sludge, or well samples, and neither the dioxins nor the PCBs found were viewed as impacting the evaluation of remedial actions at the site (Weston 1982b). 300.65(b)(5) sampling

Air Sampling

The air sampling conducted at Bruin Lagoon prior to the field investigations revealed only background organic contaminant levels. The gaseous substances, H_2S, HCN, HCL, and SO_2, were entirely undetectable at an instrument sensitivity limit of 1 ppm (mg/kg). During well drilling operations, organic vapors were detected within one boring, but were not detected 6 inches (15 cm) above the ground surface. Air monitoring throughout well installation and test pit excavations indicated safe air conditions were present at Bruin Lagoon. 300.65(b)(5) sampling

Soil Sampling

Soil samples were collected during the drilling of groundwater monitoring wells and during test pit excavation operations in the covered lagoon areas. Figure 9 300.65(b)(5) sampling

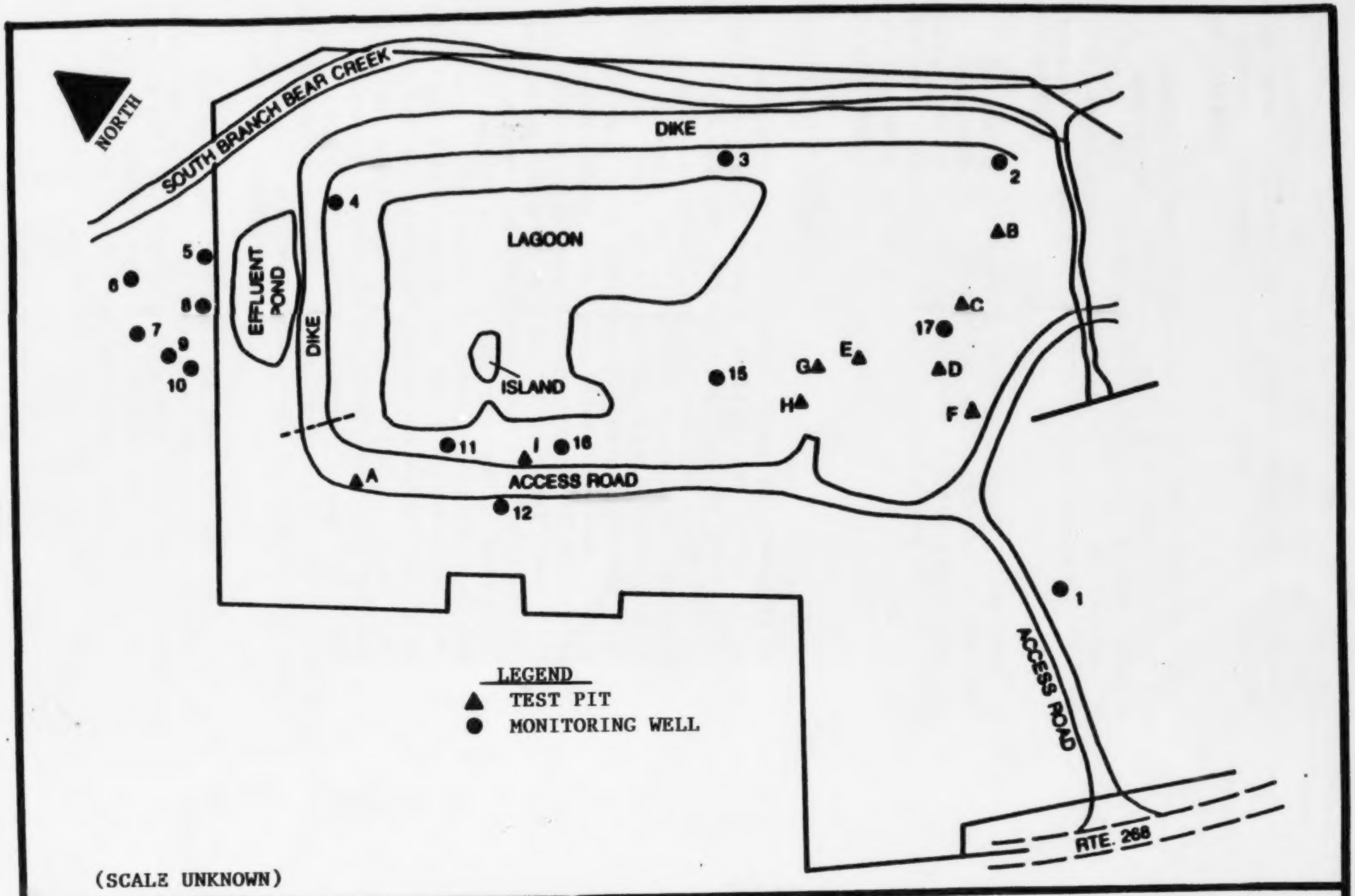


Figure 9. Soil Sampling Locations at Bruin Lagoon, Pennsylvania

Source: Weston 1982a

shows the test pit and soil boring locations. The soil samples collected were analyzed for inorganic and organic parameters. Tables 1 and 2 present inorganic and organic parameter analyses results from soil samples, respectively.

Concentrations of aluminum, barium, calcium, iron, lead, magnesium, manganese, and zinc were high in all samples. The low pH of the asphaltic sludge created acidic conditions in the soil, liberating cations of aluminum, calcium, iron, magnesium, and manganese from the soil matrix.

Few organic compounds were positively identified in the soil samples. Except for small amounts of PCB compounds that were identified in the samples taken from the abandoned storage tank areas, concentrations of identified organics were found to be within or below the 10 ppb (ug/g) range.

Surface Water Sampling

The South Branch of Bear Creek is characterized by PADER as a highly polluted small stream. This portion of Bear Creek has been severely impacted by abandoned strip and deep mine operations, oil and gas field runoff, and untreated sewage and industrial discharges. Largely as a result of local petrochemical discharges, the stream exhibits extremely high chemical oxygen demand, biochemical oxygen demand, and phenol concentrations. During low flow conditions in warm weather, the South Branch has been reported as becoming septic. The overall poor condition of the stream and knowledge that potential contaminant sources exist up and down its banks makes it very difficult to determine the specific contaminant loadings that have originated at the Bruin Lagoon site. However, an initial assessment of the stream water quality and the potential environmental impacts of the lagoon wastes on the stream was made by EPA after sampling and analyzing water samples collected upstream, along the dike, and downstream of the site. Tables 3 and 4 present surface water sample analyses results for inorganic and organic parameters, respectively.

300.65(b)(5)
sampling

The sampling results confirmed the EPA-drawn conclusion that the stream is highly polluted; however, the results were not sufficient to draw conclusions about the source of contaminants. There were significant increases in COD and TOC in samples immediately downstream from the site. Smaller contaminant increases in other inorganic parameters were also noted. These observations indicated some degree of surface water contamination as a result of

300.68(e)(3)(i)
water pollution

TABLE 1. ANALYTICAL RESULTS FOR INORGANIC PARAMETERS FROM SOIL SAMPLES COLLECTED AT BRUIN LAGOON, 24 AUGUST TO 3 SEPTEMBER 1981

Element Tested (mg/kg)	Boring No. 3 (5-6.5')	Boring No. 3 (15-20.5')	Boring No. 4 (5-6.5')	Boring No. 4 (10-11.5')	Boring No. 8 (2.5-4')	Boring No. 10 (2.5-4')	Boring No. 10 (5-6.5')	Boring No. 11 (2-4')	Boring No. 15 (8-9.5')	Boring No. 15 (15-16.5')	Boring No. 15 (19-19.5')	Boring No. 16 (4-5.5')	Boring No. 16 (5.5-7')	Boring No. 16 (7.5-10')	Boring No. 16 (10-11.5')	Boring No. 16 (15-16.5')
Aluminum	720	1,500	1,100	1,400	1,300	1,700	1,000	1,300	2,000	4,300	13,000	3,000	4,400	4,500	3,800	3,600
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	2.0	1.1	1.4	1.5	1.6	1.1	1.1	3.3	ND	6.9	3.7	5.2	5.4	5.1	4.2
Barium	34	67	78	67	32	40	100	ND	61	56	ND	75	72	48	130	79
Beryllium	0.7	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.0	1.6	ND	ND
Calcium	210	240	510	120	280	210	320	450	610	710	510	520	1,000	5,100	1,700	420
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	16	ND	8.8	11	7.1	ND
Cobalt	ND	ND	10	ND	ND	7.5	7.3	ND	8.1	13	9.5	ND	8.5	10	12	ND
Copper	6.8	7.2	ND	ND	ND	ND	ND	ND	9.1	11	9.3	7.7	19	25	15	ND
Iron	340	1,100	900	1,700	870	1,100	560	910	2,600	11,000	5,700	3,800	5,300	7,900	5,200	2,300
Lead	5.1	5.9	21	100	8.2	9.8	6.3	10	15	260	9.1	110	460	620	840	66
Magnesium	120	130	170	130	ND	ND	240	ND	180	620	350	160	450	850	310	ND
Manganese	140	57	450	110	67	320	210	72	430	340	210	280	540	450	480	81
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	ND	ND	ND	ND	ND	ND	19	16	7.6	19	19	11	7.8
Selenium	ND	ND	ND	ND	ND	ND	6.3	ND	ND	ND	1.6	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	ND	ND	ND	ND	ND	ND	ND	320	ND	330	490	410	ND	410	340	190
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tin	ND	ND	ND	ND	6.2	ND	ND	ND	6.3	12	23	ND	ND	6.3	5.8	5.3
Vanadium	ND	ND	ND	ND	ND	ND	ND	ND	ND	28	33	ND	ND	12	ND	ND
Zinc	-	-	-	-	-	-	-	ND	-	-	-	47	240	320	170	15

Note: - ND - Non detected.

Source: Weston 1982a

(continue) (continued)

TABLE 1. (Continued)

Element Tested (mg/kg)	Pit A (2')	Pit A (3')	Pit B (1')	Pit B (3')	Pit B (5')	Pit C (1')	Pit C (3')	Pit C (5')	Pit D (1')	Pit D (3')	Pit D (4')	Pit E (1')	Pit E (4')	Pit E (5')
Aluminum	3,400	2,300	1,300	4,000	3,200	1,400	2,800	640	2,800	3,400	880	1,500	620	2,300
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	1.8	2.6	22	17	3.3	2.1	2.9	2.1	22	5.8	ND	3.3	1.7	13
Barium	26	44	86	160	ND	64	61	ND	ND	120	ND	36	ND	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Calcium	380	440	1,000	34,000	9,100	3,000	1,100	910	23,000	11,000	8,800	8,700	6,500	42,000
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cobalt	ND	ND	ND	ND	ND	ND	ND	ND	8.5	13	ND	ND	ND	ND
Copper	ND	ND	8.4	14	ND	ND	ND	ND	ND	10		7.8	ND	8.0
Iron	7.0	980	1,500	2,000	3,600	1,700	2,100	4,000	3,600	2,700	1,800	2,000	350	3,200
Lead	6.2	8.1	6.1	12	150	13	12	ND	23	33	79	51	110	280
Magnesium	110	100	110	950	550	210	140	170	570	470	290	380	140	930
Manganese	49	30	21	22	120	230	220	260	210	360	110	210	30	120
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	ND	ND	ND	11	10	8.1	5.9	ND	9.5	10	ND	ND	ND	11
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	ND	ND	100	650	1,400	ND	160	430	100	810	1,200	410	1,400	800
Thallium	ND	ND	1.2	ND	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND
Tin	ND	ND	ND	31	ND	ND	5.3	ND	ND	ND	ND	ND	ND	ND
Vanadium	ND	ND	ND	18	ND	ND	ND	ND	12	12	ND	ND	ND	ND
Zinc	4.2	ND	6.2	6.4	13	8.8	4.7	ND	18	17	6.6	12	ND	33

Note: - ND - Non detected.

Source: Weston 1982a

(continued)

(continued)

TABLE 1. (Continued)

Element Tested (mg/kg)	Surf. Soil Williams	Pit F (2')	Pit F (4')	Pit F (5')	Pit G (1')	Pit G (3')	Pit G (5')	Pit H (8')	Pit H (3')	Pit H (4.5')	Pit I (1.5')	Pit I (3')	Pit I (4')
Aluminum	1,600	2,500	2,400	1,700	4,200	2,700	2,000	2,100	6,600	1,800	1,800	1,700	340
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	8.1	4.9	2.5	1.6	6.9	7.0	4.8	2.4	12	2.2	2.2	3.0	
Barium	100	80	71	61	39	44	ND	62	ND	52	59	4.7	ND
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Boron	-	-	-	-	-	-	-	-	-	-	-	-	-
Cadmium	ND	ND	ND	ND	ND	ND	ND	ND	2.6	ND	ND	2.0	ND
Calcium	4,100	520	550	660	38,000	20,000	23,000	7,100	150,000	770	510	4,500	23,000
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	8.8	ND	ND	ND	6.7
Cobalt	ND	9.0	ND	ND	ND	ND	ND	ND	11	ND	ND	ND	ND
Copper	13	7.5	ND	ND	7.1	ND	ND	ND	14		18	13	ND
Iron	3,000	4,000	1,900	2,600	2,300	2,000	3,500	1,700	2,900	1,100	1,400	1,400	340
Lead	62	24	7.1	10	710	29	120	37	58	ND	10	570	13
Magnesium	850	ND	ND	160	1,100	540	720	320	2,700	250	280	620	600
Manganese	270	280	540	140	260	340	230	440	160	230	370	280	37
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	6.8	ND	ND	ND	ND	8.3	ND	6.8	30	ND	ND	ND	7.7
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sodium	310	ND	340	ND	180	280	880	230	250	ND	450	440	5,600
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tin	7.2	ND	5.4	ND	5.2	ND	ND	ND	6.1	ND	6.9	ND	ND
Vanadium	ND	11	ND	ND	12	11	ND	ND	15	ND	ND	ND	ND
Zinc	31	14	6.2	4.7	19	31	29	9.2	12	40	14	20	ND

Note: - ND - Non detected.

Source: Weston 1982a

TABLE 2. ANALYTICAL RESULTS FOR PRIORITY ORGANICS FROM SOIL SAMPLES COLLECTED AT BRUIN LAGOON, 24 AUGUST TO 3 SEPTEMBER 1981

Organic Compound (µ g/g)	Williams Surface Soil	Boring No. 3 (5-6.5')	Boring No. 3 (15-20.5')	Boring No. 4 (5-6.5')	Boring No. 6 (10-11.5')	Boring No. 8 (2.5-4')	Boring No. 10 (2.5-4')	Boring No. 10 (5-6.5')	Boring No. 11 (2-4')	Boring No. 15 (8-9.5')	Boring No. 16 (4-5.5')	Boring No. 16 (5.5-7')	Boring No. 16 (7.5-10')	Boring No. 16 (10-11.5')	Boring No. 16 (15-16.5')
ACID COMPOUNDS															
PHENOL												5.6	<0.2		2.1
BASE/NEUTRAL COMPOUND															
1, 2, 4 TRICHLOROBENZENE															1.7
HEXACHLOROBENZENE							<0.20								
1, 2 - DIPHENYLHYDRAZINE							<0.20								
FLUORANTHENE	<0.20														
4 - CHLOROPHENYL PHENYL ETHER							<0.20								
4 - BROMOPHENYL PHENYL ETHER							<0.20								
N - NITROSODIPHENYLAMINE							<0.20								
BIS (2-ETHYLHEXYL) PHTHALATE	<0.20												1.1		
DIETHYL PHTHALATE							<0.20								
DIMETHYL PHTHALATE							<0.20								
BENZO (A) ANTHRACENE	<0.20														
CHRYSENE	<0.20														
ANTHRACENE	<0.20						<0.27						1.5		0.2
FLUORENE							<0.20								
PHENANTHRENE	<0.50						<0.27						1.5		0.5
PYRENE	<0.50														
VOLATILES															
BENZENE											0.03	0.03	0.03		0.01
CHLOROBENZENE					<0.01								0.01		0.01
1, 1, 1 - TRICHLOROETHANE												0.02			0.01
CHLOROETHANE											0.01	0.01	0.01		0.01
ETHYLBENZENE											0.07	0.06	0.05		0.03
METHYL CHLORIDE	0.01	0.02	0.03	0.05	0.024	0.012	0.023	0.01	0.01	0.036	0.01		0.01	0.01	0.02
BROMOMETHANE													0.01		
BROMOFORM													0.01		
TRICHLOROFLUOROMETHANE	0.01				<0.01										
TETRACHLOROETHYLENE											0.05		0.01		0.01
TOLUENE	0.01	0.01	0.12		0.096	0.052	0.016	<0.01	0.01	0.027	0.22	0.16	0.30		0.13
TRICHLOROETHYLENE											0.02	0.05	0.04		0.03
PESTICIDES - -															
PCB-1242												1.79	1.47		
PCB-1260	0.053											5.61	5.50		0.10

Note: < - Value indicates no concentration detected at test limit.

Source: Weston 1982a

TABLE 2. ANALYTICAL RESULTS FOR PRIORITY ORGANICS FROM SOIL SAMPLES COLLECTED AT BRUIN LAGOON, 24 AUGUST TO 3 SEPTEMBER 1981

Organic Compound (µ g/g)	Williams Surface Soil	Boring No. 3 (5-6.5')	Boring No. 3 (15-20.5')	Boring No. 4 (5-6.5')	Boring No. 4 (10-11.5')	Boring No. 8 (2.5-4')	Boring No. 10 (2.5-4')	Boring No. 10 (5-6.5')	Boring No. 11 (2-4')	Boring No. 15 (8-9.5')	Boring No. 16 (4-5.5')	Boring No. 16 (5.5-7')	Boring No. 16 (7.5-10')	Boring No. 16 (10-11.5')	Boring No. 16 (15-16.5')
ACID COMPOUNDS															
PHENOL												5.6	<0.2		2.1
BASE/NEUTRAL COMPOUND															
1, 2, 4 TRICHLOROBENZENE															1.7
HEXACHLOROBENZENE							<0.20								
1, 2 - DIPHENYLHYDRAZINE							<0.20								
FLUORANTHENE	<0.20														
4 - CHLOROPHENYL PHENYL ETHER							<0.20								
4 - BROMOPHENYL PHENYL ETHER							<0.20								
N - NITROSODIPHENYLAMINE							<0.20								
BIS (2-ETHYLHEXYL) PHTHALATE	<0.20												1.1		
DIETHYL PHTHALATE							<0.20								
DIMETHYL PHTHALATE							<0.20								
BENZO (A) ANTHRACENE	<0.20														
CHRYSENE	<0.20														
ANTHRACENE	<0.20						<0.27						1.5		0.2
FLUORENE							<0.20								
PHENANTHRENE	<0.50						<0.27						1.5		0.5
PYRENE	<0.50														
VOLATILES															
BENZENE											0.03	0.03	0.03		0.01
CHLOROBENZENE					<0.01								0.01		0.01
1, 1, 1 - TRICHLOROETHANE												0.02			0.01
CHLOROETHANE											0.01	0.01	0.01		0.01
ETHYLBENZENE											0.07	0.06	0.05		0.03
METHYL CHLORIDE	0.01	0.02	0.03	0.05	0.024	0.012	0.023	0.01	0.01	0.036	0.01		0.01	0.01	0.02
BROMOMETHANE													0.01		
BROMOFORM													0.01		
TRICHLOROFLUOROMETHANE	0.01				<0.01										
TETRACHLOROETHYLENE											0.05		0.01		0.01
TOLUENE	0.01	0.01	0.12		0.096	0.052	0.016	<0.01	0.01	0.027	0.22	0.16	0.30		0.13
TRICHLOROETHYLENE											0.02	0.05	0.04		0.03
PESTICIDES - -															
PCB-1242												1.79	1.47		
PCB-1260	0.053											5.61	5.50		0.10

Note: < - Value indicates no concentration detected at test limit.

Source: Weston 1982a

TABLE 3. PRIORITY INORGANICS AND SPECIAL ANALYSES FROM SURFACE WATER SAMPLES COLLECTED AT BRUIN LAGOON 24 AUGUST TO 3 SEPTEMBER 1981

Element tested	Bear Creek downstream (mg/L)	Bear Creek base of dike (mg/L)	Feeder stream (mg/L)	Bear Creek upstream (mg/L)
Aluminum	20.7	0.65	0.15	5.0
Antimony	<0.02	<0.04	<0.02	<0.02
Arsenic	0.12	0.03	<0.01	0.03
Barium	3.87	2.39	0.06	2.72
Beryllium	0.006	<0.002	<0.002	0.002
Boron	0.10	0.12	0.02	0.10
Cadmium	<0.005	<0.005	<0.005	<0.005
Calcium	241	55	27.2	74.1
Chromium	0.20	<0.01	<0.01	0.02
Cobalt	0.09	<0.01	<0.01	0.01
Copper	0.66	<0.02	<0.02	0.04
Iron	164	5.50	0.60	58
Lead	0.10	0.05	<0.04	<0.05
Magnesium	38	10.8	6.40	13.5
Manganese	7.9	1.01	0.18	1.7
Mercury	<0.001	<0.001	<0.001	<0.01
Nickel	0.24	<0.02	<0.02	0.04
Selenium	0.02	0.10	<0.01	<0.02
Silver	<0.02	<0.02	<0.02	0.01
Sodium	946	906	6.10	820
Thallium	<0.10	<0.04	<0.01	0.01
Tin	0.009	<0.50	<0.04	<0.04
Vanadium	0.05	<0.01	<0.01	0.02
Zinc	1.12	0.05	0.39	0.12
COD	11,400	3,730	<5	1,910
TOC	3,586	1,266	8	454
MBAS	475	775	0.1	510
TS	4,780	4,690	270	3,880
VS	1,420	1,530	84	800
Cyanide	<0.01	<0.01	<0.01	<0.01

Note: < - Value indicates no concentration detected at test limit.

Source: Weston 1982a

TABLE 4. PRIORITY ORGANICS FROM SURFACE WATER SAMPLES COLLECTED AT BRUIN LAGOON, 24 AUGUST TO 3 SEPTEMBER 1981

Organic Compound (ug/L)	Downstream	Northeast Lagoon	Feeder Stream	Upstream
Acid Compounds				
Phenol	310	28	--	37
Base/Neutral Compounds				
Anthracene	--	12	--	<10
Phenanthracene	--	12	--	<10

Note: < - Value indicates no concentration detected at test limit.

Source: Weston 1982b

Bruin Lagoon. Upstream samples contained greater than 1 ppm (mg/l) concentration of aluminum, barium, magnesium, and manganese and greater than 50 ppm (mg/l) concentrations of calcium, iron and sodium. Three potential mechanisms were identified for the observed increases in surface water contamination:

300.64(a)(2) identification of source and nature of release

- Direct surface runoff from open and closed lagoon areas
- Subsurface seepage through the dike located between the lagoon and Bear Creek
- Groundwater seepage into the creek.

The first two mechanisms were potential avenues for contaminants; however, no surface runoff or seepage was observed during the field investigations. EPA therefore concluded that the increase in surface water contamination was potentially being caused by contaminated groundwater flowing below the lagoon into Bear Creek.

Groundwater Sampling

Fourteen groundwater monitoring wells were installed at the Bruin Lagoon site by EPA during the remedial investigation. These wells were located upgradient and downgradient from the site, adjacent to the lagoon, and along the dike separating the lagoon and Bear Creek. Eight "shallow" wells intercepted the groundwater table within the soil overburden, and six "deep" wells intercepted groundwater in the fractured sandstone bedrock (Figure 10). Groundwater from the site and adjacent properties was analyzed for priority inorganic and organic pollutants and special inorganic parameters. Table 5 presents analytical results for priority inorganic contaminants and other inorganic parameters, and Table 6 gives the organic pollutant concentrations observed in groundwater samples. Based on sampling results, EPA made the following observations regarding the extent of groundwater contamination and migration:

300.68(f)
sampling and
monitoring

300.68(e)(2)(ii)
extent of
migration of
substances

- Although downgradient groundwater contamination has resulted from the presence of the Bruin Lagoon sludge, there were existing elevated inorganics in the background well.

- Shallow groundwater was more highly contaminated than deep groundwater. Approximately one order of magnitude difference existed between the inorganics in the two groundwater regimes.

- Primary drinking water standards for arsenic, barium, cadmium, chromium, lead, and mercury were exceeded in shallow groundwater samples immediately downgradient from the site. However, the shallow groundwater is not used locally for drinking purposes.

- Contaminant levels varied across the site area, and pollutant migration was shown to exist from sampling results from downgradient wells.

- Downward vertical groundwater flow at the site was being caused by mounding in the open lagoon and posed potential downward contaminant migration problems.

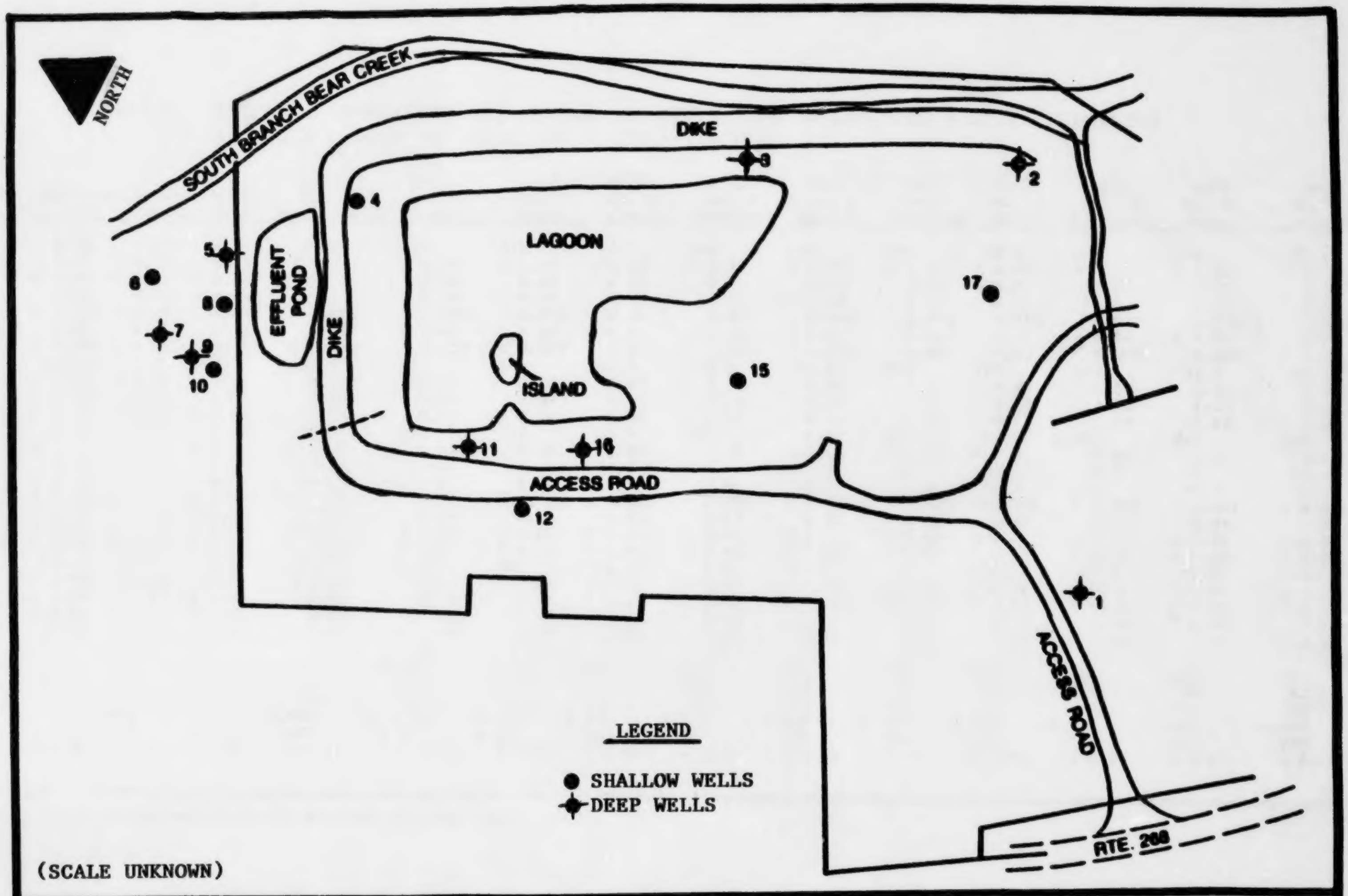


Figure 10. Locations of Deep and Shallow Wells at Bruin Lagoon, Pennsylvania

Source: Weston 1982a

TABLE 5. PRIORITY INORGANICS AND SPECIAL ANALYSES FROM GROUNDWATER SAMPLES COLLECTED AT BRUIN LAGOON 24 AUGUST TO 3 SEPTEMBER 1981

Element tested (mg/L)	Williams Well	Reider Well	Moser Well	Well No. 1 (background)	Well No. 2 (deep)	Well No. 3 (deep)	Well No. 5 (deep)	Well No. 6 (shallow)	Well No. 7 (deep)	Well No. 8 (shallow)	Well No. 9 (deep)	Well No. 10 (shallow)	Well No. 11 (deep)	Well No. 16 (deep)
Aluminum	0.05	0.15	0.20	38.8	393	124	82.7	154	111	341	28.5	372	249	26.2
Antimony	2 < 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.10	< 0.02	< 0.10	< 0.02	< 0.02
Arsenic	< 0.01	< 0.01	< 0.01	0.01	0.30	0.05	0.05	0.05	0.04	0.06	< 0.01	0.13	0.10	0.02
Barium	0.08	0.15	0.09	0.37	0.48	0.30	0.17	1.51	1.70	2.17	0.15	10.8	1.44	0.15
Beryllium	< 0.002	< 0.002	< 0.002	0.004	0.006	0.006	< 0.01	0.008	0.008	0.018	0.016	0.028	0.018	0.004
Boron	0.01	0.01	0.05	0.02	< 0.01	0.02	0.01	0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01	0.03
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005	0.015	< 0.005	0.01	0.005	0.005	0.005	0.02	< 0.005	0.005	0.005
Calcium	39.6	21.4	43.1	28.9	130	162	93.4	79.5	66.6	128	182	334	51.1	60.0
Chromium	< 0.01	< 0.01	< 0.01	0.07	0.33	0.19	0.05	0.21	0.14	0.46	0.07	1.00	0.31	0.06
Cobalt	< 0.01	0.11	0.01	0.16	0.24	0.09	0.72	0.32	0.48	0.46	1.16	2.80	1.12	0.29
Copper	< 0.02	< 0.02	< 0.02	0.12	0.11	0.08	0.08	0.18	0.16	0.42	0.12	0.84	0.48	0.02
Iron	0.40	6.90	5.98	50.8	607	205	85.9	294	0.20	801	56.5	1,360	283	109
Lead	< 0.05	< 0.05	< 0.04	< 0.05	0.24	0.05	0.05	0.08	< 0.05	< 0.05	< 0.05	0.05	0.20	< 0.05
Magnesium	6.70	7.20	6.90	9.30	72.5	35	21.6	23	29.6	68	32.3	99.7	32	17.7
Manganese	0.01	5.38	0.93	34.2	22.0	6.70	57.7	19.9	30.7	56.6	46.3	130	30.7	16.7
Mercury	< 0.001	< 0.001	< 0.001	< 0.001	0.01	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001	< 0.001
Nickel	< 0.02	0.04	< 0.02	0.12	0.30	0.12	0.32	0.24	0.44	0.70	0.46	1.50	0.46	0.21
Selenium	< 0.01	< 0.01	< 0.01	< 0.01	< 0.10	< 0.02	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01	< 0.02	< 0.01	< 0.01
Silver	< 0.02	< 0.02	< 0.02	< 0.02	< 0.25	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Sodium	24.4	27.9	39.4	12.8	163	158	44.2	9.3	22.1	32	36.1	45.5	46.8	94.5
Thallium	< 0.01	< 0.01	0.01	< 0.01	0.01	< 0.05	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.05
Tin	< 0.02	< 0.02	< 0.02	< 0.02	0.50	< 0.20	< 0.20	< 0.02	< 0.02	< 0.02	< 0.02	< 0.25	< 0.04	< 0.20
Vanadium	< 0.01	< 0.01	< 0.01	0.07	0.44	0.22	0.02	0.28	0.18	0.64	0.01	0.72	0.29	0.03
Zinc	0.40	0.25	0.05	0.67	1.68	1.34	2.82	1.55	1.47	3.72	2.03	7.71	4.48	3.28
pH (Units)	---	---	---	---	---	---	---	---	---	---	---	---	---	---
COD (mg/L)	---	15	< 5	55	2,420	410	1,090	1,130	490	975	540	1,290	150	310
TOC (mg/L)	18	22	26	18	620	100	320	380	140	---	170	260	88	94
MBAS (mg/L)	---	0.1	< 0.1	2.3	110	12	51	79	43	36	23	98	37	10
TS (mg/L)	---	300	107	3,980	12,600	6,330	4,580	8,290	7,930	5,800	3,230	6,120	1,600	1,810
VS (mg/L)	---	107	103	207	7,360	3,430	1,140	853	730	490	590	590	310	500
Cyanide (mg/L)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	---	< 0.01	< 0.01	< 0.01	< 0.01

Note: < - Value indicates no concentration detected at test limit.

Source: Weston 1982a

TABLE 6. PRIORITY ORGANICS FROM GROUNDWATER SAMPLES COLLECTED AT BRUIN LAGOON
24 AUGUST TO 3 SEPTEMBER 1981

Orangic compound (μg/L)	Williams Well	Reider Well	Moser Well	Well No. 1	Well No. 2	Well No. 3	Well No. 5	Well No. 6	Well No. 7	Well No. 8	Well No. 9	Well No. 10	Well No. 11	Well No. 16
Acid Compounds														
Pentachlorophenol			<10									<10		
Phenol					<10	<10								
Base/Neutral Compounds														
Flouranthene												<10		
Isophorone							17						43	24
N-Nitroso-diphenylamine	<10	<10		15								21		
Bis (2-Ethylexyl) Phthalate					<10	<10		21		16			32	
Diethyl Phthalate						<10								
Dimethyl Phthalate													11	
Phenanthrene			<10									13		
Pyrene												14		

Note: < - Value indicates no"concentration detected at test limit.

Source: Weston 1982a

PLANNING THE SITE RESPONSE

Initiation of Site Response

Attention began to focus on the Bruin Lagoon site in 1968 when American International Refining Company reinforced the lagoon's dike after a 3,000-gallon (11,533-l) spill. Other interim improvements were attempted in the 1970's, although most were unsuccessful. In March 1979, upon completion of a dike wall stability evaluation, a State contractor recommended further study. A detailed technical assessment of the site by a second firm found that environmental threats from leachate overflow coexisted with the potential for dike failure. At that time, the State did not have the resources for the necessary actions, although they were able to get A.H.-R.S. Coal Company to sign two consent decrees, the first requesting lagoon stabilization and capping and the second requiring the company to petition bankruptcy court for administrative expenses to clean the site. The company did not comply with either agreement, and since the lagoon continued to pose an imminent environmental and health hazard, EPA initiated an emergency response in September 1981.

Region III's involvement with the Bruin Lagoon site began earlier in 1981 on two levels. In April, Region III and State personnel drafted guidelines to begin developing a community relations plan, although no local activities were to be undertaken until specific study information became available. Additionally, in May 1981, EPA's FIT contractors developed a final work plan for the Bruin Lagoon study project. The statement of work was broken down into three segments:

- An investigation of site characteristics, quantity of lagoon contents, and their analysis
- A Feasibility Study
- Development of engineering criteria for design and contracting purposes.

The need to evaluate and monitor soil and groundwater underneath the lagoon after the response effort was completed was also noted.

Responsibilities designated to PADER included:

- Selecting a project officer
- Participating with EPA in the development of a project schedule
- Developing a community relations plan in a joint effort with EPA
- Providing access to the site and the necessary file information
- Providing inter-departmental coordination, any State permits, and legal support, as available.

EPA was to:

- Select all contractors for the response effort
- Take the lead on enforcement actions
- Manage daily operations.

During June 1981, Region III's Hazardous Site Control Division received approval to issue funds to the EPA's contractor for a remedial investigation and a feasibility study (RI/FS) of cleanup alternatives. The RI began in July to examine the extent of groundwater, surface water, air, and soil contamination. A Feasibility Study, evaluating five alternative remedial actions, was delivered in Jaunary 1982.

A public meeting was held in Bruin County on February 10, 1982 to discuss the RI/FS and to answer technical and policy-related questions put forward by local officials and area residents. Shortly thereafter, representatives from EPA and PADER met to discuss the cleanup strategy. It was decided that additional investigative field work was necessary in order to make further recommendations. As a result, EPA's contractor prepared a report on the dike's stability, a report on the area's flooding potential, and an environmental analysis. Based on this information, EPA made a "finding of no significant impact" of the proposed remedial action and formally recommended the cleanup option. An action memorandum approving the selection of the waste containment cleanup option was signed by the Assistant Administrator of the U.S. EPA's Office of Solid Waste Emergency Response on June 8, 1982.

A second public meeting was held in July during which EPA announced that it would set aside Superfund money for a remedial contract for Bruin Lagoon. The amount was amended in September and an agreement was signed with the U.S. Army Corps of Engineers to let and manage that contract, as well as to oversee actual on-site activities. Also in September, a formal notice letter was sent to A.H.-R.S. Coal Company by EPA Headquarters, informing them of their liability for the costs incurred during cleanup at the site.

After selecting on-site containment (consisting of stabilization of the existing dike; removal and disposal of supernatant, contaminated soil, and tanks; and construction of a multilayer cap system), preliminary designs were drafted. It appeared that several technical problems remained to be addressed and, consequently, EPA had its contractor undertake supplemental investigations. The additional field work, a pilot sludge stabilization study, a sampling and inventory of the contents of abandoned tanks on-site, and a survey of cross-sections of Bear Creek to calculate the level of probable floods in the creek's watershed were completed in January 1983. On January 18, 1983, a public meeting was held to discuss the results of these studies, and in March, final design documents were delivered.

Soon after, the EPA and the State were able to draw up a legal agreement with A.H.-R.S., restricting the use of the site area for 30 years while granting access to the appropriate personnel for construction and long-term monitoring and maintenance. On April 4, 1983, a State Superfund Contract was signed.

The next phase in the sequence of events leading up to the actual response effort began in May with the ACE formally advertising for construction bids, and a site visit June 8, 1983 for all interested contractors. On August 2, 1983, the contract was awarded and the next week another public meeting was held.

In addition to announcements made at the four public meetings, news regarding the Bruin Lagoon site was disseminated to the public regularly via press releases (issued by the State and EPA) and from local media coverage. Beginning in June 1981, Region III personnel made frequent site visits and later explained site activities to area residents, local officials, and community leaders.

In response, copies of the dike stability report were made available, and groundwater monitoring wells were installed to monitor any off-site migration of contaminants. The entire program was explained at length and copies of the safety plan were distributed to interested parties. EPA and PADER took the citizens' concerns into consideration while formulating a final community relations plan for the Bruin Lagoon site, completed in 1983.

Selection of Response Technology

300.68(g)
development of
alternatives

The selection of remedial response technologies for the Bruin Lagoon site was carried out with the aid of a feasibility study prepared by an EPA contractor in January 1982. The study initially identified a wide range of potential technologies available to clean up Bruin Lagoon. This range of technologies was then reviewed and screened on the basis of technical feasibility, cost-effectiveness, implementation timeframe, and environmental effectiveness. Institutional factors and safety considerations that might impact implementability were also considered. The initial screening process identified nine potential strategies for remedial action at Bruin Lagoon. Table 7 describes each of the nine alternatives that were considered and gives the rationale for either their acceptance or rejection during the final selection process.

From the initial nine strategies, five were eliminated during the second screening process. The remaining four strategies, described in detail in Table 7, included:

- Waste Fixation
- Waste Encapsulation
- Excavation and Off-site Disposal
- Waste Containment.

As the result of detailed evaluations subsequently conducted, EPA ranked the four options from most to least acceptable:

(1) Waste Containment
(2) Excavation and Off-site Disposal
(3) Waste Encapsulation
(4) Waste Fixation.

The strategy that was finally selected for implementation at Bruin Lagoon was waste containment, incorporating both surface management and lagoon stabilization techniques to control wastes at the site. The primary goal of this strategy was to control infiltration into the contaminated areas, minimizing leachate generation and dispersion, and thereby controlling groundwater flow and contaminant migration.

Table 7 goes here

TABLE 7. ALTERNATIVE REMEDIAL STRATEGIES, BRUIN LAGOON, PENNSYLVANIA

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
1. Incineration[r]	Onsite or offsite incineration of open lagoon materials	• Both onsite and offsite options eliminated because of lengthy implementation timeframe • Mobile incinerator to burn type of waste at site not generally available • Very high costs associated with both onsite and offsite options	300.70(C) offsite transport for destruction
2. Groundwater Controls[r]	Active and passive groundwater controls: Active • Extraction • Injection Passive • Bottom sealing • Interception trenching* • Cutoff walls	• Drinking water wells not contaminated from Bruin Lagoon wastes • Background groundwater quality shows contamination • Most groundwater flowing under site is discharged to Bear Creek, and Bear Creek is signficantly more contaminated than the groundwater and will remain so for the forseeable future • Absence of continuous impermeable geologic layer under site to use for tie-in of passive controls • Vertical upward head and mounding would not be affected by passive controls	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(iii)(c) groundwater pumping

(continued)

a - accepted

r - rejected

* - Groundwater interceptor trench was selected as part of Strategy #9, however, it was not implemented because of subsequent evaluation results.

TABLE 7. (continued)

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
3. Groundwater Treatment[r]	Physical, chemical and biological methods were examined	• High O&M costs • Little or no positive impact on quality of the ground or surface water in area because of overall contamination in area	300.70(b)(2)(ii) direct waste treatment methods
4. Land Treatment[r]	Land application of supernatant and sludge	• Acidic nature of wastes would prohibit growth of microorganisms required for biodegradation	
5. Treatment and Utilization for Energy Recovery[r]	Burning sludge for energy recovery by firms in area	• High associated costs • Proposed processing technology would have had to be demonstrated and proven first	
6. Waste Fixation[r]	Excavate sludge, mix it with an agent to chemically stabilize the waste, redeposit in lagoon, construct clay cap over lagoon	• Asphaltic and viscous sludge presented severe mixing difficulties from a mechanical standpoint • Complete mixing and blending required for chemical fixation could not be assured • Depth of lagoon (15-18 ft.) presented accessibility problems in mixing the lower layers of sludge • Heterogenous nature of sludge/soil mixture in covered lagoon area coupled with varying moisture contents presented technical problems with mixing ratios • Limited past experience in applying in situ fixation to this type of heavy sludge in a deep lagoon	300.70(b)(2)(iii)(E)(2) neutralization
7. Waste Encapsulation[r]	Excavate sludge, install liner under lagoon, redeposit sludge, and construct a multilayer cap	• Presents same excavation and handling uncertainties as Alternative #6 (see above)	300.70(B)(1)(iii)(D)(3) liners 300.70(b)(1)(ii)(A) surface seals

a - accepted

r - rejected

(continued)

TABLE 7. (continued)

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
8. Excavation with Offsite Disposal[r]	Two disposal options included: • Disposal as hazardous waste • Treat and dispose as solid waste	• Both disposal options have very high associated costs	300.70(c)(1)(ii) offsite transport; capacity to manage hazardous wastes
9. Waste Containment[a]	Surface management (SM) and lagoon stabilization (LS) techniques designed to accomplish in situ isolation of contaminated lagoon areas SM Techniques • Demolition and offsite disposal of storage tanks • Offsite disposal of PCB-contaminated residues • Excavation of contaminated surface soils • Construction of embankment slope stability improvements LS Techniques • Removal and offsite disposal of supernatant • Stabilization of open and closed lagoon areas with additives such as lime, fly ash, kiln dust or soil • Application of a multilayer cap system over site • Construction of groundwater interceptor trench*	• Least costly of all the remedial action scenarios because no waste handling or movement is required • Implementation time frame is short-term; it was estimated that between 6 months to 1 year was required to complete implementation • Eliminates lagoon overflow threat to surface water • Ponding will be eliminated with use of cover system	300.70(b)(2)(ii)(B)(3) neutralization 300.70(b)(2)(iii)(c) solidification

a - accepted

r - rejected

* - Groundwater interceptor trench was selected as part of Strategy #9, however, it was not implemented because of subsequent evaluation results.

The surface management techniques selected as part of this remedial strategy included: the demolition and off-site disposal of the abandoned storage tanks, off-site disposal of PCB-contaminated residues, excavation of contaminated surface soils, and construction of embankment slope stability improvements. Lagoon stabilization techniques that were selected consisted of: removal and off-site disposal of supernatant, physical stabilization and closure of the open lagoon and the closed lagoon area, application of a multilayer cover system over the site, and construction of a groundwater interceptor trench.

The components selected as part of the waste containment strategy were subject to various changes as site operations proceeded. Most of the changes involved minor alternations in design; however, in the case of one of the components, the groundwater interceptor trench, the entire component was eventually eliminated from the program.

The groundwater interceptor trench was designed to intercept uncontaminated groundwater flowing towards the site from the southwest and divert it around the open lagoon area, eventually discharging into Bear Creek (Figure 11). The use of the trench would aid in minimizing leachate generation. However, there were several problems with the design of this technology that would have adversely affected its performance at the Bruin Lagoon site. The following concerns were the main reasons for the elimination of the groundwater interceptor from the remedial program:

- The design was such that the trench would not penetrate the full depth of the aquifer, and therefore would have no effect on the downgradient water table.

- The trench would not cut off all flow into lagoon area because (1) it was designed almost parallel to the direction of groundwater flow, and (2) its lineal extent made it such that it was only upgradient of a portion of the site.

- Recharge to the site not only occurs from the west, but also from Bear Creek; therefore, controlling the water table and leachate generation beneath the site would also require controlling recharge from the stream.

- The design was such that the trench would intercept lagoon-mounded groundwater at the site,

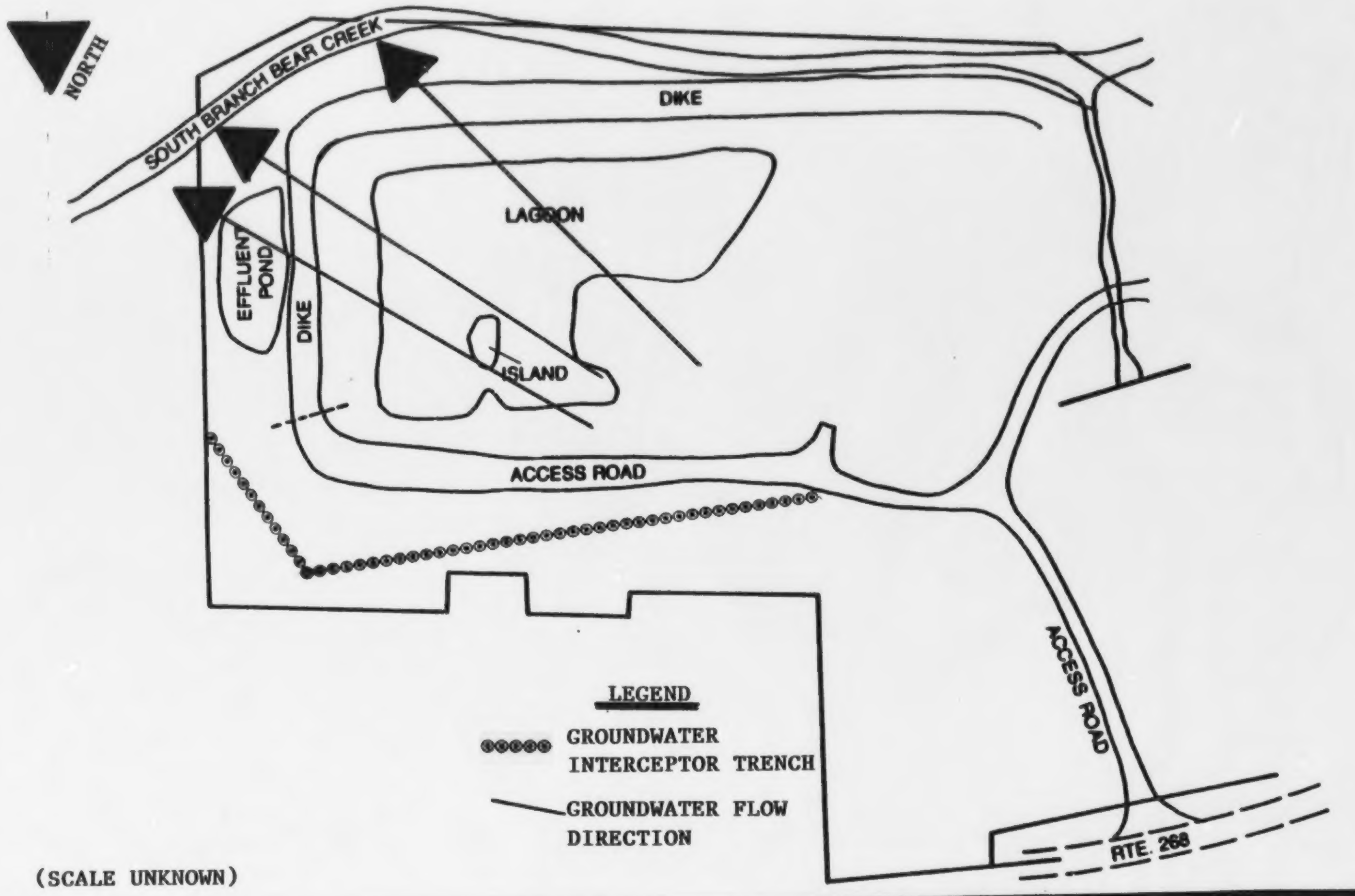


Figure 11. Location of Proposed Groundwater Interceptor Trench, Bruin Lagoon, Pennsylvania

Source: Weston 1983b

and discharge it to Bear Creek; groundwater treatment and a NPDES discharge permit, therefore, would have been required.

In addition to the design problems described above, a decision made regarding the sludge stabilization process turned out to be a large factor in the decision to eliminate the trench from the program. Originally, the scope of work for remedial operations specified that only the upper 10 feet (3 m) of sludge be stabilized. The decision to stabilize the entire volume of sludge instead of only a portion of it was made and, as a result of this decision, the groundwater interceptor trench was deemed unnecessary because groundwater coming in contact with completely stabilized sludge would not create a leachate problem.

The other components of the waste containment strategy are presently in various stages of implementation. Additional technologies and changes in work schedules have been instituted since remedial operations began at the site because of unanticipated site conditions. The design and the execution of remedial actions at Bruin Lagoon are discussed in detail in a subsequent section.

Extent of Response

300.68(j)
extent of remedy

Elimination of the source of contamination, i.e. the lagoon itself, as well as the contaminated dike, is the final cleanup objective for remedial work at the Bruin Lagoon site. By removing the volume of contaminated material in and around the lagoon, the environmental impact of the polluted area will be minimized and the potential threat posed by that material--as evidenced by the 1968 spill and the 1984 hydrogen sulfide gas release--will be negated.

A secondary consideration was a reduction in the threat of groundwater contamination, although that element could not be addressed before stabilizing the lagoon and thereby removing the source of ongoing contamination.

Remedial work at the site will continue until the objective is achieved. The completion of the remedial work was originally scheduled for the spring of 1985; however, since the initial remedial contract was terminated, and work under the new contract did not begin until December 1984, the completion date has been pushed forward. Under the second remedial contract, EPA is responsible for monitoring and maintenance at the site.

After EPA has completed remedial actions at the site, these responsibilities will be turned over to PADER for the next 30 years.

DESIGN AND EXECUTION OF SITE RESPONSE

The first site response initiated by EPA at Bruin Lagoon was an emergency action taken in September 1981 in response to a potential overflow problem at the dike along Bear Creek. The emergency response consisted of the following three activities:

- Addition of fill material to raise berm elevations around the lagoon to prevent future overflow problems

  300.70(b)(1)(ii)
  (B)(1)
  dikes and berms

- Erosion control along the outer faces of the lagoon berms (i.e., placement of riprap)
- Construction of a discharge line from the lagoon to the effluent pond and from the pond to the stream.

  300.70(b)(1)(ii)
  surface water
  controls

The emergency response activities commenced on September 5, 1981 and were completed September 21, 1981.

The second response initiated at the Bruin Lagoon site consisted of the waste containment strategy that began in September 1983, and at the time of this writing, had not been completed yet. The early design of the waste containment strategy was completed in October 1982, and identified several technical problems that needed to be addressed during furture design phases. To solve these problems, EPA and PADER decided to perform on-site pilot studies of specific waste stabilization techniques, additional sampling and inventory of the tanks, and a detailed study of flooding potential. These studies were completed in January 1983 and final design documents were delivered in March 1983.

300.70(b)(1)(ii)
(A)
surface seals
300.70(b)(2)(ii)
direct waste
treatment

The next phase of the remedial program was initiated by the Army Corps of Engineers on May 25, 1983 when the plans and specifications were advertised for bids. The work to be performed included the following principal features:

- Dispose of storage tanks and railroad tankers
- Dispose of contaminated liquids and other acidic and asphaltic supernatant

- Stabilize sludge with pozzolan

- Install an interceptor drain (later deleted from remedial program)

- Stabilize embankment with riprap and gabions, and construct a concrete retaining wall between the lagoon embankment and the stream

- Cap with geotextile fabric, gravel, and clay layers

- Cover with topsoil and seed.

The Bruin Lagoon remedial contract was awarded on August 3, 1983, and the contractor was given a notification to proceed on September 27, 1983. With construction time limited by the contract to 161 days from the notice to proceed, the project was expected to be completed not later than March 6, 1984.

On September 28, 1983 on-site preparation work was initiated by the contractor. This phase involved the following activities:

- Grubbing, clearing, rough grading, and application of dust suppressant

- Upgrading of site access roads

- Installation of 6-foot (2-m) high site boundary fence

- Installation of water lines

- Establishment of a water treatment facility for drinking water and decontamination wash water

- Installation of two holding tanks for septic wastes and wash water from decontamination activities

- Removal of abandoned storage tanks in Area 1

- Removal of contaminated soil from Area 1

- Construction of erosion and runoff controls, i.e., containment berms, stone filter berms, and runoff diversion swales

- Establishment of temporary office and parking areas (Area 1)
- Establishment of a decontamination area (Area 2).

Site preparation activities were completed by October 31, 1983. The general site layout is shown in Figure 12.

300.65(b)(6)
moving hazardous
substances
off-site

The removal of supernatant from the open lagoon area commenced on November 1, 1983. The following day, on November 2, 1983, preparation for tank demolition and disposal activities was initiated. These two activities had originally been planned to be undertaken concurrently. However, because there were delays associated with the issue of tank ownership and the question of whether or not additional tank testing would be required, the actual tank demolition/disposal activities did not commence until November 21, 1983.

The removal of supernatant from the open lagoon and effluent pond areas generally proceeded without delays. Compatible 6,000-gallon (23,000-1) tanker trucks and a pump and piping system were utilized to remove the aqueous acidic wastes. Supernatant was pumped into one truck at a time (there were usually five or six trucks on-site at one time) from the southwest corner of the open lagoon, adjacent to the truck loading area (see Figure 12). Every truck load of supernatant was partially neutralized inside the truck using caustic soda. The effluent pond liquids, approximately 146,000 gallons (550,000 1), were first pumped into the open lagoon area and then the combined liquids were pumped into the truck. Every tank truck load carried about 5,400 gallons (20,000 1) of supernatant for off-site treatment and disposal.

By November 18, 1983, supernatant removal operations at Bruin Lagoon were essentially complete, with approximately 500,000 gallons (1.8×10^6 1) having been removed. Over the next 5 months, however, before sludge stabilization began, precipitation collected in the open lagoon and an additional 500,000 gallons (1.8×10^6 1) of acidic liquid were generated. This additional liquid was also pumped and transported off-site, bringing the total quantity of supernatant removed from the site to 1×10^6 gallons (3.8×10^6 1).

The initiation of tank demolition/disposal activities was delayed 3 weeks, during which time EPA finalized the contractual agreement between EPA, the Corps of Engineers, and the Corps' contractor to complete these specific activities. On November 21, 1983, EPA contractors assumed the task of removing the contents of all of the tanks

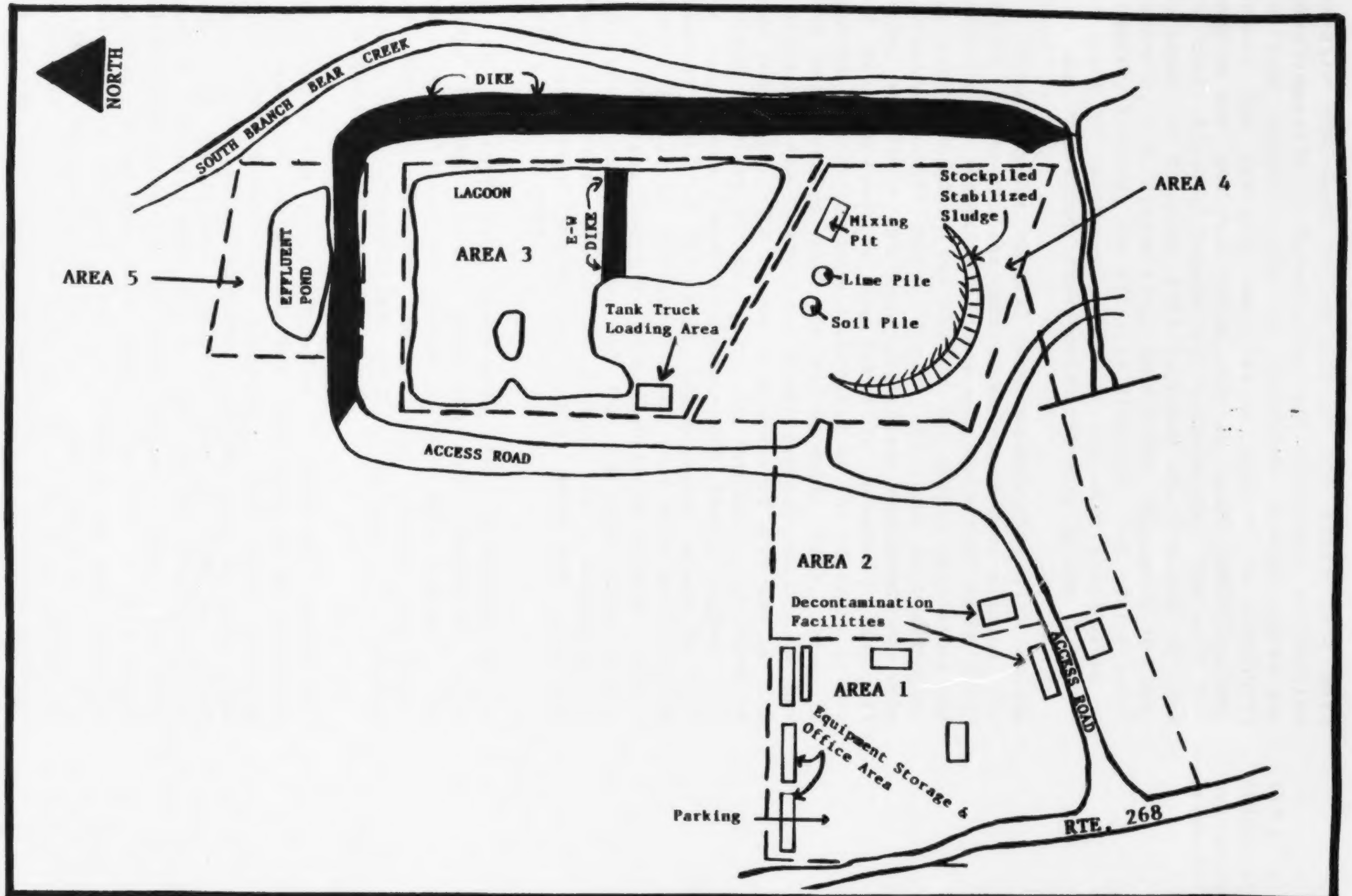


Figure 12. General Site Layout, Bruin Lagoon, Pennsylvania

Source: USEPA 1984

on-site and demolishing all of the tanks that were unsalvageable. Demolition and disposal activities involved approximately 40 abandoned storage tanks and drums. The residual material in many of the containers sampled and analyzed during earlier field investigations to meet disposal regulatory requirements. The work that followed in November 1983 included the removal of tank contents, tank dismantling, demolition, temporary storage, removal, hauling, and off-site disposal. Out of the total of about 40 tanks, only five or six were salvageable in tact and, therefore, transported off-site in one piece.

300.67(c)(3)
hazardous
substances in
drums and tanks

Tank residue removal was accomplished with vacuum trucks. After the contents of each tank were removed, the interior was inspected for any materials that might fall. The tank atmosphere was checked for oxygen deficiency and gas-tested before entry. During all flame cutting operations, special respiratory protection equipment was worn and every precaution was taken to ascertain that all sources of ignition were controlled in the vicinity of any tank being worked on. By mid-December 1983, about 85 percent of the tank demolition/disposal activities had been completed. The reason this phase of work was not 100 percent complete at this point was twofold: (1) three of the tanks were found to contain PCB levels higher than original tests had indicated, which caused delays for disposal, and (2) 20 additional drums that were not included on the original inventory were identified on-site. The 3 PCB-contaminated tanks and the 20 additional items remained on-site until late March 1984. Consequently, tank demolition/disposal activities were not completed until mid-April 1984.

By the third week in November 1983, excavation of the sludge in the effluent pond area had commenced. The excavated material was placed in the open lagoon. The effluent pond and open lagoon sludge mixture was subsequently used for stabilization pilot testing, which began on December 1, 1983.

During the period December 1, 1983 to January 12, 1984, numerous pilot tests were conducted using different stabilization material mixtures. The three primary pozzolans (solidifying agents) tested were fly ash, kiln dust, and quicklime. Initial results from the pilot studies indicated that fly ash was not the most effective solidifying agent for the Bruin Lagoon sludge. The next pozzolan tested was kiln dust. The use of this agent achieved the desired results; however, the cost of this material was excessively high, and therefore it was eliminated as a viable alternative. Finally, quicklime was tested, and by mid-January 1984, a lime-soil mixture had been derived that met both performance and cost requirements. However, actual stabilization activities did not begin until April 1984. Although the pozzolan mixture had been successfully designed by the end of January 1984, the stabilization process also required different specifications than originally planned, and a contract modification had to be negotiated. The completion of these tasks required the months of February and March.

Another remedial activity that was initiated at Bruin Lagoon in the latter months of 1983 was the improvement of the open lagoon embankments. Embankment improvement work began at the south end of the project area and involved the construction of a concrete retaining wall along the stream side of much of the dike separating the lagoon and Bear Creek. Approval to begin the construction of the retaining wall in the southeast corner of the project area was given on December 27, 1983. A 100-foot (30.5-m) work area was allowed, leaving a 100-foot (30.5-m) buffer to the open lagoon. On December 28, 1983, the benching of the embankment began to remove the existing riprap for the construction of the first 60 feet (18 m) of the wall. On January 5, 1984, approval was given to begin work on the north embankment slope, along which riprap was placed. Work along the embankment slopes continued through most of the month of January until questions were raised regarding worker safety in relation to the stream bed sediments. The site health and safety officer stopped the work on the wall on January 27, 1984 until chemical analyses of the stream sediments were conducted and the necessity for added worker protection during the completion of the wall was determined. Ninety feet of the wall had been constructed by the end of January 1984.

On January 31, 1984, all work at the Bruin Lagoon site was halted, not to resume again until April 1984. The 2-month lapse in operations at the site was due to work specification and contractual changes that had become necessary.

The stabilization process originally proposed was redesigned and respecified during the months of February and March 1984. The decision had been made to reject the originally planned in-situ stabilization process, which involved stabilization of the upper 10 feet (3 m) of sludge only and to accept an out-of-lagoon mixing technique to stabilize all the sludge down to the top of bedrock. As a result of the changes made to the remedial plan, a contract modification had to be negotiated. Work began at the site under a newly devised contract 2 months later.

The next phase of remedial activities at the Bruin Lagoon site began in April 1984 and primarily involved excavation and stabilization of the sludge in the open lagoon area. In addition, embankment improvement work resumed, and transportation and treatment of supernatant liquid that ponded in the lagoon sump continued as precipitation dictated. On April 9, 1984, the sludge stabilization process began in the southeast section of the open lagoon (Area 3).

The open lagoon exhibited little apparent physical bearing capacity. Sludge depths in the open lagoon were estimated to range between 10 and 15 feet (3.1 and 4.6 m) in the western portion to about 20 feet (6.1 m) in the eastern portion, adjacent to the lagoon embankment. (Sludge depths were based on a conservative evaluation that sludge material extended to bedrock). The estimated volume of sludge in Area 3 was 35,000 cubic yards (26,760 m^3).

To facilitate the sludge stabilization operation, a shale dike was constructed across the southern portion of the lagoon in an east-west direction (see Figure 12). The plan had been to first remove and to stabilize the sludge from the area south of the dike. This area would then be backfilled with stabilized sludge, providing a stable surface on which to work to complete excavation and stabilization of the sludge remaining in the northern portion of the lagoon.

The mixing of the sludge and the lime/soil additive was performed out of the open lagoon area in a pit located in the closed lagoon (see Figure 12). Sludge was progressively removed from Area 3 using a truck-mounted clam shell crane and transported to the mixing/stabilizing pit. The powdered lime used for stabilization was delivered to the site on a daily basis and stored in a pile located adjacent to the mixing pit. The soil additive was also trucked into the site each day and stored in a pile near the pit (see Figure 12). The sludge/lime/soil ratio by weight that was used during mixing to achieve optimal results was 1:0.17:1. An average of 66 tons (60 metric tons) of lime and 388 tons (352 metric tons) of soil were mixed with 388 tons (352 metric tons) of sludge per day during the stabilization process.

The sludge/lime/soil combination was mixed in the pit using two crawler-mounted backhoes and then stockpiled at the south end of the open lagoon area (see Figure 12). The plan was to first stabilize the sludge in the portion of Area 3 south of the E-W dike, and then backfill this portion with stabilized sludge. In this manner, an area was created that would support heavy equipment for the remainder of the sludge stabilization work to be done in the open lagoon north of the E-W dike.

One of the main problems during the stabilization process was the generation of airborne particles consisting of soil and lime dust and, on several occasions, chemical vapor generated from the reaction between the sludge and the lime additive. The generation of chemical vapor was controlled by limiting the amount of lime added at one time. The initial action taken to control the dust problem was covering the soil and lime storage piles with uncontaminated, dismantled tank parts. This action minimized the dust created by the wind blowing across the lime storage pile; however, dust was still generated when lime was transported to the mixing pit and during actual mixing. By mid-April 1984, the decision was made to stop using powdered lime and begin using a larger pellet form. Dust generation was minimized as a result of this decision.

During the stabilization and backfilling process, work personnel wore cloth overalls and organic vapor respirators at all times. Continuous environmental monitoring was conducted using an OVA, which was carried around the site, and TENAX absorbent tubes, which were in operation 3 days out of every week. Each week the tubes were sent to an off-site laboratory for analysis.

The sludge stabilization process progressed at a steady rate through the month of April 1984. By the first week of May 1984, about 30 percent of the sludge in the open lagoon had been stabilized. The area south of the E-W dike was almost entirely excavated and sludge excavation had begun north of the dike. On May 4, 1984, during the excavation of sludge in the most southeast portion of the open lagoon, there was a sudden release of acid gas, later identified as hydrogen sulfide gas. The protective respiratory equipment worn at that time by the contractor personnel was ineffective, and operations under the remedial contract were suspended until the problem was better characterized.

At this time, the second emergency response was initiated at the Bruin Lagoon site to address the unexpected gas problem. In June 1984, EPA's Zone II contractor mobilized on-site and installed four borings to better define the underlying conditions. An unexpected crust layer ranging from nearly nonexistent to about 2 feet (0.6 m) thick was discovered at an average depth of 18 feet (5.5 m) (about 5 feet or 1.5 m above bedrock). Between the crust layer and bedrock was an additional layer of sludge. At this point in the investigation of the gas problem, one hypothesis was that the pockets of hydrogen sulfide gas existed within the newly discovered sludge layer between the crust layer and bedrock.

After the installation of the borings was completed and the general nature of the problem was established, EPA's emergency contractor was notified and mobilized on-site in July 1984 to backfill the open lagoon area and to stabilize the situation so that heavy equipment could be supported. By July 22, 1984, the entire open lagoon area was backfilled with the stabilized sludge that had been stockpiled. Following the completion of this task, EPA contracted with a firm that had demonstrated expertise in hydrogen sulfide gas problems. EPA had decided that the situation required further definition before the remedial program that had been underway could continue. The action that followed commenced on July 27, 1984 and involved exploratory drilling and the installation of a total of 13 gas venting wells. Ten of these wells were located in the open lagoon area and three were installed in the closed lagoon (Figure 13). The initial exploratory drilling was conducted to locate any existing pockets of gas. Any gas located would then be vented through a specially designed treatment scrubber system that was connected to the drill rig. There were no significant gas pockets of high volume identified in the lagoon.

Drilling and gas well installation activities continued for about 3 weeks, concluding by the third week in August 1984. Numerous series of gas samples have been collected and analyzed. Chemical analysis results do not indicate that there is a large amount of hydrogen sulfide gas present; rather, SO_2 gas is much more abundant. The conclusion drawn from data collected during the emergency response was that there was no imminent danger to the community or to the environment because of the existence of the gas, and it was not expected that there would be in the future. However, EPA directed its emergency response personnel to continue monitoring the site during September 1984 by collecting additional gas samples for analysis.

300.68(e)(2)(i)
extent of threat
to health,
welfare, or the
environment

The conclusion that had thus far been drawn was that there was no building up of confined pockets of gas in the Bruin Lagoon that posed an imminent hazard to public health or to the environment. Instead, it was believed that the gases were being released as soon as they were generated. It is believed that the gases were reaction products resulting from contact between water and the highly acidic sludge.

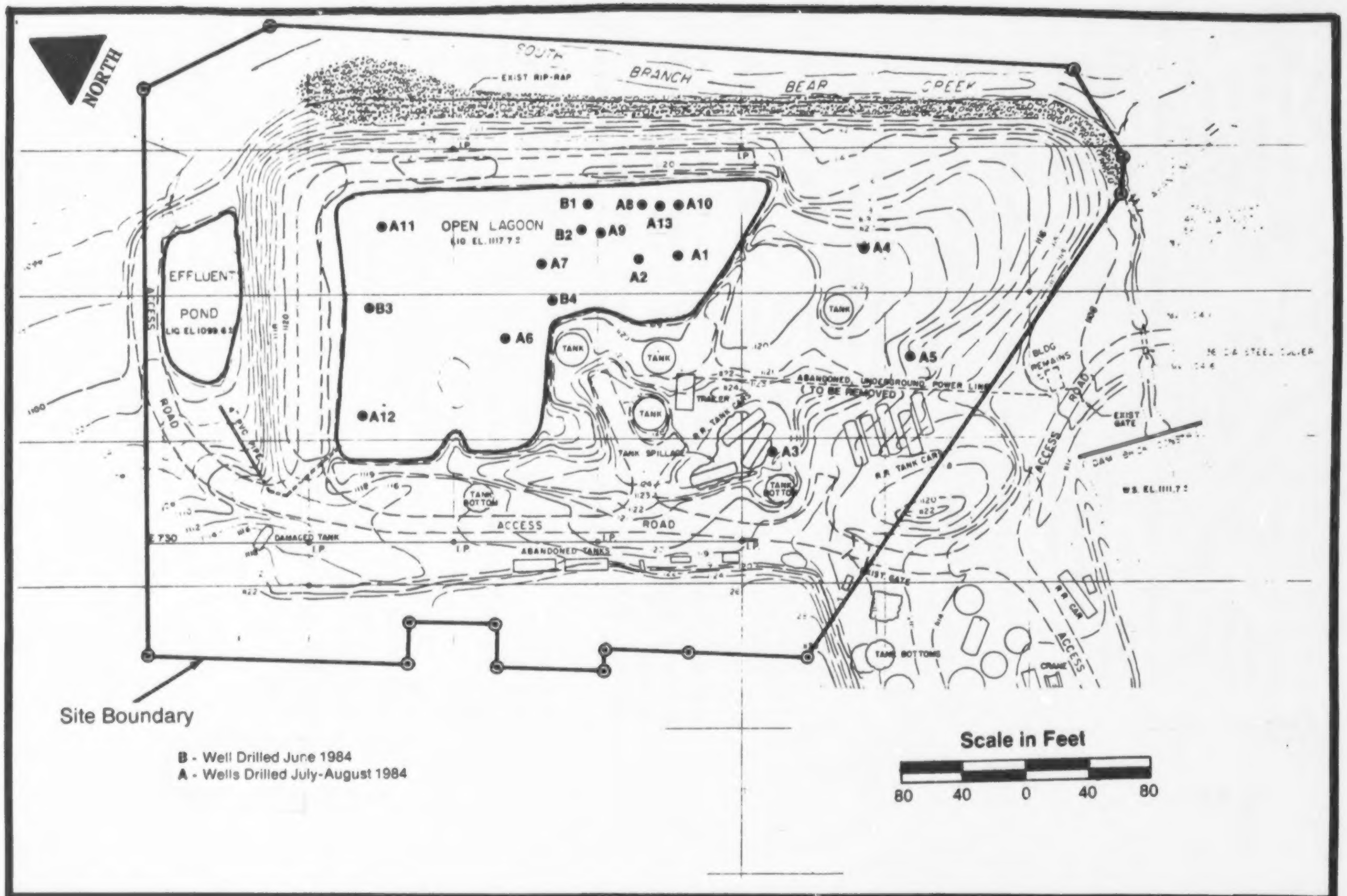


Figure 13. Locations of Borings and Gas Venting Wells, Bruin Lagoon, Pennsylvania

Source: USEPA 1984

During the third week in September 1984, the remedial action contract and contractor were officially terminated. EPA had decided that it was necessary to reevaluate the site conditions and to redesign any further remedial work to be implemented at the site. It was planned that a new remedial contract would be let out for bids in the fall of 1985. Because a revised remedial contract would not be out for at least the next 6 months, EPA chose to use the existing removal contract as the monetary vehicle for the implementation of three critical tasks before the end of September 1984. These tasks were as follows:

300.66(a)
assessment for
further action

- Additional gas sampling and analysis
- Completion of the existing chain-link security fence around the lagoon
- Partial slope stabilization (i.e., riprap and gabion installation).

COST AND FUNDING

Source of Funding

All of the previously noted studies prepared for DER during the 1979-1980 initial investigation of the problem at Bruin Lagoon were paid for by the State. One exception, the technical report developed by JRB Associates, was supported with Region III's RCRA budget.

300.62(a)
state role

Due to a lack of adequate resources, the State was unable to implement the actions recommended by their own consultants or EPA's consultants, and therefore turned to EPA for assistance.

Pre-Superfund/RCRA monies were committed for the next phase at Bruin Lagoon involving the RI/FS and the design of a remedial alternative. Initially, the agreement arrived at by the State and EPA was not one of cost sharing. During the period soon after the passage of CERCLA in December 1980, it was not yet clear what activities the State's 10 percent share would go towards. As such, without more definitive terms for what the law required, PADER had reservations about entering into an open-ended cooperative commitment. Instead, a memo of understanding was signed in the summer of 1981 that did not require any matching funds from PADER. However, they were expected to manage the project to the extent that their financial and technical resources would allow, and both parties signed under the assumption that at some future date, CERCLA funds would be available for implementation of the actual cleanup at the site.

A contractor was ordered to begin the RI after RCRA money was obligated in July 1981. As the Statement of Work changed over the course of the project (including supplemental field investigations), additional funds became available from this same source. The cost of emergency removal in September 1981 was covered with emergency CERCLA funds. After more concrete State Superfund contract guidelines were made available, the agreement between the State and EPA changed. On June 6, 1982, Pennsylvania's Secretary of Environmental Resources sent a letter to Region III's Hazardous Materials Toxic and Pesticides Branch confirming the intent of PADER to provide for its 10 percent share of the CERCLA matching fund.

300.61(c)
CERCLA-financed
response

EPA's State Superfund contract guidance, developed in March 1982, mandates that before the design work on a remedial alternative begins, a State Superfund contract must be signed. Since Bruin Lagoon was one of the first CERCLA hazardous waste sites to receive Superfund money, the program was not as strict as it is today. An exemption was granted for the Bruin site because, with the project initiated and scoped out well before publication of the guidance document, the contractor reached the design stage far in advance of any final State Superfund contract being developed. In July 1982, with RCRA funds obligated from the summer before, EPA's contractor began work on the remedial design. This also prevented a delay in EPA and the ACE entering into an inter-agency agreement.

Also in July 1982, Region III submitted a proposed civil action to Headquarters for recovery of the 1981 emergency removal response costs pursuant to Section 107 of CERCLA. EPA is attempting to recover the remedial costs has incurred at the lagoon, but it is unlikely that it will be able to recoup any money.

Superfund dollars are supporting all remedial work at Bruin Lagoon, including the ACE contract.

Selection of Contractors

One result of the 1968 sludge spill was that the Bruin Lagoon site became the focus of much community attention, unsolicited studies, and extensive media coverage. The State, with a similar concern over the site's hazard potential, contracted out with GAI Consultants, Inc. of Pittsburgh, Pennsylvania and Rollins Environmental Services of Deer Park, Texas (in 1979 and 1980, respectively) to perform technical evaluations. However, these studies were limited due to financial constraints. Evidence revealing or supporting the rationale behind the selection of those two particular firms was lacking, although one source noted that both are very competent and well-respected in their fields.

Under the Technical Assistance Panel (TAP) contract with EPA Region III, JRB Associates conducted a technical assessment of potential remedial measures for the Bruin Lagoon site during the period from April 1979 to April 1980. JRB Associates was awarded the Region III TAP contract through a competitive bid process.

Late in 1980, PADER invited the Mitre Corporation of Bedford, Massachusetts to submit a proposal, which they did in January 1981, to assist in evaluating technologies and procedures for the lagoon cleanup. However, in the aftermath of Bruin Lagoon being chosen as a Superfund candidate, EPA Regional and Headquarters personnel decided instead to use Roy F. Weston, Inc. (West Chester, Pennsylvania), their Zone II contractor, to study the lagoon.

EPA also opted to use the U.S. Army Corps of Engineers instead of a private firm to provide technical assistance during the design phase. It assisted in this manner because the project had progressed substantially before the EPA/Corps agreement was signed.

H.J. Schneider Construction, Inc. of Pittsburgh, Pennsylvania (and subcontractor VFL Technology of Malvern, Pennsylvania) was selected as the remedial contractor through a regular competitive bidding process. Having been engaged in all types of heavy construction for over 30 years--including Clean Water Act projects for EPA--Schneider had acquired a sufficient expertise and a broad range of equipment suited to handle the Bruin Lagoon project. Schneider's bid was $1.2 million below the highest and $0.5 million below the average bid from five bidders. Schneider was selected on the basis of being "responsive" and "responsible."

For the emergency response, O. H. Materials Company of Findlay, Ohio, EPA's Emergency Response Cleanup Services (ERCS) contractor, was brought on-site. Two subcontractors from Texas were asked to assist the ERT. Because few firms in the area had a solid background in dealing with hydrogen sulfide, EPA had to look beyond the east coast for a firm with this expertise. Enviro-Safe, Inc. and Bob Wells of Blow Out, Inc., two east coast firms with experience in hydrogen sulfide gas problems, were recommended by the American Petroleum Institute, and were hired.

Project Cost

To date, the total cost for the initial 1981 emergency response and 1984 remedial response at the Bruin Lagoon site is approximately $1.75 million. Included in this figure and discussed below are the following:

- Initial Investigations
- Emergency Removals
- Remedial Investigation/Feasibility Study
- Site Preparation
- Tank Work
- Liquid Supernatant Removal Activities
- Lagoon Stabilization
- Embankment Improvements.

Table 8 gives a project cost breakdown based on these work areas.

All of the information is based on contractor invoices and progress reports, U.S. EPA documents, and personal communication with U.S. ACE personnel. The U.S. ACE, responsible for technical supervision during the remedial response, is to receive up to $342,000 via the inter-agency agreement signed with EPA when the remedial work is completed. All costs are in current year dollars (with the exception of maintenance costs) and have not been adjusted.

Noted here are two categories that were not calculated into the total project cost for the Bruin Lagoon site. They are (1) maintenance and monitoring; and (2) the 1984 emergency response action. Expected maintenance and monitoring costs are in 1983 dollars and are as follows: $12,000/year broken down into $6,500/year for maintenance and $5,500/year for monitoring. These activities will continue for a duration of 30 years. At 1983 present worth cost and based on a 7.375 percent discount rate, the total cost for the period is calculated to be $76,000 for maintenance and $65,000 for monitoring, or $141,000 in total.

In regard to the 1984 emergency action at the site, final project expenditures were approximately $935,000. Furthermore, the remedial contractor has claimed that due to work suspension, he is entitled to $2000 each day in lost revenue. At the time of the case study site visit, ACE officials estimated that the total claim was approximately $100,000.

Table 8 goes here

TABLE 8. PROJECT COST SUMMARY
BRUIN LAGOON, BRUIN BOROUGH, PENNSYLVANIA

Task	Quantity	Estimate	Actual Expenditure	Unit Cost	Period of Performance	Source of Funding
I. RESEARCH & DEVELOPMENT AND CAPITAL						
A. Initial Investigation	--	--	$15,000.00+	--	1979-1980	RCRA/State
B. Emergency Removal (1981)	--	--	$20,038.95	--	Sept. 1981	Emergency CERCLA
C. RI/FS (includes remedial design)	--	$252,355.00	$319,805.60	--	July 1981-Jan 1982; April, May 1982 and Oct. 1982 - Jan. 1983	Pre-Superfund/ RCRA and CERCLA
D. Site Preparation	--	$320,000.00	$328,801.00	--		CERCLA
E. Tank Testing, Demolition, Disposal	20 Tank Items	$70,832.00	$74,835.32	--	Oct. 1983 - April 1984	CERCLA
F. Contaminated Liquids o Collection o Disposal	1,668,305 gal supernatant 203,765 gal washwater	$111,075.00	$374,414.00	$.20/gal	Oct. 1983 - March 1984	CERCLA
G. Lagoon Stabilization	6444 tons	$562,575.00	$248,100.00	$38.50/ton	Dec. 1983 - Arpil 1984	CERCLA
H. Embankment Improvements	--	$244,241.00	$34,117.00	--	Oct. 1983 - May 1984	CERCLA
I. Final Grading and Cover	--	$426,057.00	N/A	--	--	CERCLA
J. Technical Assistance U.S. ACE	--	$342,000.00	$342,000.00	--	--	CERCLA
K. Emergency Removal (1984)	--	$350,000.00	$935,000.00	--	--	CERCLA
TOTAL R&D AND CAPITAL			$1,757,111.87			
II. OPERATION AND MAINTENANCE						
A. Maintenance B. Monitoring		$6,500.00/year $5,500.00/year				CERCLA
TOTAL O&M		$12,000.00/year				CERCLA

Source: USACE 1984c

Initial Investigations

In March 1979, a dike stability study was conducted and a final report was prepared for the State. The cost of this study was not available at the time of this writing. In 1981, EPA's contractor conducted a technical study of the lagoon and assessed alternative remedial alternatives. The total cost of this study was approximately $15,000.

Emergency Removal

A total of $20,038.95 was spent on the 1981 removal action. There were no records available at the time of this writing due to ongoing status of project offering a cost breakdown.

Remedial Investigation/Feasibility Study

Originally, the contract awarded for the Remedial Investigation/Feasibility Study was not to exceed $252,355. However, as can be seen in Table 8, the total cost was close to $320,000; $67,455 or 27 percent over the planned amount. Additional field investigations and site work which were beyond the original scope of work were requested by EPA because they were needed to complete the project and to properly prepare the waste containment bid specifications.

As noted in Table 9, the cost of start-up and initial tasks, including the collection of background information and the development of safety and site contingency plans, amounted to $45,450. The total for the Remedial Investigation field studies, $51,200, included a topographic and geophysical survey; monitoring well installation; sampling of surface water, groundwater, and waste; soil sample borings; and digging backhoe test site.

The planned total for the Feasibility Study was $53,600, while the actual total came to $67,550.60. The $13,955.60 overrun is accounted for with $9,344 for the development and the evaluation of a dike stability report and $4,611 for preliminary work in the evaluation of probable maximum flood (PMF) conditions at the site.

TABLE 9. REMEDIAL INVESTIGATION/FEASIBILITY STUDY AT BRUIN LAGOON, BRUIN BOROUGH, PENNSYLVANIA

1.	Start-up and Initial Tasks	$ 45,450.00
2.	Remedial Investigation Field Work	$ 51,200.00
3.	Feasibility Study	$ 67,550.60
4.	Remedial Design	$155,605.00
	Total	$319,805.60

Source: Roy F. Weston 1981-1983

The last phase of the project, the remedial design, was the largest cost component. This included selecting a remedial alternative, and developing an implementation plan, the engineering design, and a bid package. This phase was delayed due to the addition of three separate tasks not included in the original scope of work. Additional work, described below, increased the cost by $53,500, for a total combined cost of $155,605. Specifically:

- To accurately assess the quantity of abandoned storage tank material and contaminated residuals over 40 tanks had to be opened and sampled. The total cost was $14,000.
- A pilot sludge stabilization study was undertaken at a cost of $19,500.
- After a preliminary analysis of the PMF conditions at the lagoon, it was decided that detailed modeling with a computer would provide a more accurate analysis. The PMF study was $20,000.

Site Preparation

Site preparation costs were approximately $320,000 based on a cost breakdown furnished by the contractor. Activities under this category included repairing the site access road, providing a parking area, erecting a fence around the site, and setting up various waste, decontamination, and testing and office facilities.

Tank Work

The total for tank demolition and disposal at the Bruin Lagoon site was $74,835.32. There are four components to this figure. The first component was $1,555.13 for off-site disposal of 21.75 tons (19.74 metric tons) of contaminated tank materials (with a $71.50 per ton unit cost.) The second component was the off-site disposal of the contents of these tanks at $12,300; 9840 gallons (37244 1) of contaminated liquid was disposed of at a unit cost of $1.25 per gallon. The third item was $80.19 for disposal of 80.19 tons (72.99 metric tons) of noncontaminated tank material ($1.00/ton unit cost), and the fourth item was a lump sum of $60,900 for all other tank demolition and disposal work.

Liquid Supernatant Removal Activities

Currently, the total cost to collect and to dispose of the liquid supernatant and contaminated washwater at the lagoon is $374,414. This amount is $260,000 more than the initial cost estimate for these activities and may increase even further if the additional monies sought after by the removal contractor are granted. A substantial cost overrun was related to the excessive quantity of liquids collected and disposed (the contract cost estimates were for 446,000 gallons (168,810 1) of supernatant and 80,000 gallons (302,800 1) of washwater). Table 10 offers a partial breakdown of actual costs together with a comparison of expected and actual costs.

Lagoon Stabilization

After several trials and changes to the mix design and the choice of additive, a revised stabilization process was selected. Before work was suspended, a total of 6444 tons (5850 metric tons) of sludge was stabilized at a total cost of $248,100. The neutralizing process cost was $101,815; 40 percent of the total cost. The remaining 60 percent involved $114,227 for 1109 tons (1007 metric tons) of quicklime, $10,392 for 2108 tons of soil bulking agent, and $21,166 for 2659 tons (2414 metric tons) of a soil/pozzolan mix. A change in the design mix, proposed by the contractor's subcontractor, offered a substantial savings of $314,475 less than what the originally selected mix would have cost. According to officials, the data in Table 10 are based on the best available data to date.

TABLE 10. COLLECTION AND DISPOSAL OF CONTAMINATED LIQUIDS AT BRUIN LAGOON, BRUIN BOROUGH, PENNSYLVANIA

	Expected Number of Gallons (Liters)	Actual Number of Gallons (Liters)	Unit Cost	
A) Supernatant	446,000 (1.68×10^6)	1,668,305 (6.3×10^6)		
Collection			$.12/gal	($200,196.60)
Disposal			$.08/gal	($133,464,40)
				$333,661.00
B) Washwater	80,000 (3.02×10^5)	203,756 (7.7×10^5)	$.12/gal	$24,451.80)
			$.08/gal	($16,301.20)
				$40,753.00
			Total:	$347,414.00

Source: USACE 1984c

Embankment Improvements

To date, approximately $34,000 has been spent on work done on the premises toward reinforcing and strengthening the embankment at the Bruin Lagoon site. Within the original contract, almost $245,000 was set aside for this project. The $34,000 figure is a small percentage (approximately 14 percent) of the amount proposed by the contractor and reflects the work completed to date. See Table 11 for a unit and total cost comparison for embankment improvements.

As noted in Table 11, construction of 92 feet (28 m) of a concrete retaining wall was the bulk of the expenses at approximately $31,000, or 91 percent of the total spent thus far. Placing riprap along the embankment, at $22.50/cy, cost $1688, or 51 percent of the current amount expended. The remaining 4 percent is divided between excavation activities ($450) and attending to the existing riprap ($375) at the site.

TABLE 11. EMBANKMENT IMPROVEMENTS AT
BRUIN LAGOON, BRUIN BOROUGH, PENNSYLVANIA

Item	Unit Price	Quantity (cy)	Total
Remove, sort, stockpile existing riprap	$5.00/cy	75	$375¯
Excavation (Shaping embankments)	$3.00/cy	150	450¯
Filter Geotextile	$1.50/cy	--	--
Stone Bedding Blanket	$24.00/cy	25	600¯
Riprap (placed)	$22.50/cy	75	1,688¯
Concrete Wall	$337¯/cy*	92	$31,004¯

*This unit price is actually a work item; it includes excavation, placement of concrete forms, cost of concrete structures, etc.

Source: USACE 1984c

PERFORMANCE EVALUATION

At the time of this writing, the remedial response at Bruin Lagoon had not yet been completed. The unexpected gas conditions at the site required that further assessments be made regarding site conditions and a new remedial contract be devised. At the time of this writing, it had not yet been decided what additional remedial measures would be necessary to achieve the overall objective of eliminating the lagoon as a source of contamination. Because remediation at the Bruin Lagoon site was incomplete, the following section only presents a partial evaluation of the effectiveness of the remedial measures implemented at the site. It also discusses some of the delays and problems involved in the implementation of the program thus far, in hope that knowledge gained through these accounts will benefit the implementation of future remedial response programs at other sites.

The most critical and most recent delay in the remedial program at Bruin Lagoon (fall-winter, 1984-1985) was caused by unexpected site conditions. The late identification of gaseous material and an additional sludge layer leads one to believe that perhaps the initial investigative studies were not as thorough as they might have been. Had the crust layer and the additional sludge been identified before the sludge stabilization process had begun, the gases would also have been noted earlier, and perhaps later problems and delays could have been avoided.

The unexpected conditions at the site not only caused a delay in the overall schedule of the remedial program, but also led to the lagoon being backfilled before all of the contaminated sludge had been excavated and stabilized. Only 30 percent of the sludge in the open lagoon had been stabilized when that process was halted and it was decided to backfill the entire open lagoon area. At the present time, it has not been decided whether the stabilized sludge will have to be reexcavated in order to stabilize the underlying contaminated sludge.

Since the first emergency action was taken at the site in response to a dike leakage problem in September 1981, there have been no reported incidents of sludge leakage into the stream, nor have there been any overflow problems. Also, in its present dry state, i.e., all the supernatant having been removed, there is no possibility that there will be any future overflow problems. Because all of the sludge had not yet been stabilized, there was the potential for future sludge leakage into the stream if the integrity of the lagoon embankments was not upheld. At the time of this writing, all precautionary and remedial measures had been taken to ensure increased longevity of the lagoon embankments. There were, however, two threats to the stream that still existed. One was posed by contaminated groundwater, although the extent to which groundwater would become contaminated by contact with unstabilized sludge in the lagoon was undetermined at this time. The other threat was posed by sludge that was oozing to the surface of the site. The sludge upwelling was being visually monitored daily. There have been no reports of sludge overtopping the embankment; however, there was the problem of surface water coming in contact with the sludge and producing acidic runoff, which could have affected the stream. At the time of this writing, no further conclusions could be drawn regarding the lagoon's potential threat to the environment prior to the completion of an additional RI/FS study that was being conducted.

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DENNEY FARM SITE

BARRY COUNTY, MISSOURI

INTRODUCTION

NCP References

The Denney Farm site, also known as Farm Site 1, is located on a 160-acre (65-ha)[1] farm in rural southwestern Missouri. It is in Barry County, approximately seven miles south of Verona, Missouri. During June and July of 1971, employees of the Northeastern Pharmaceutical and Chemical Company (NEPACCO), whose manufacturing facility was located in space leased from Hoffman Taff, Inc., since taken over by Syntex Agri-business, Inc., disposed of still bottoms and other wastes produced in the company's manufacture of the bactericide hexachlorophene. An estimated 80 to 90 drums of this waste, which contained 2,3,7,8-tetrachlorodibenzo-para-dioxin, also known and referred to here, as TCDD or dioxin, were discarded in a trench that was approximately 10 feet (3 m) wide, between 50 and 60 feet (15-18 m) long, and generally less than 6 feet (1.8 m) deep. Eye witnesses reported that at the time of disposal, some of the drums were deteriorating and much of the waste material was later found to have leaked from the drums.

300.68(e)(2)(1) (B) amount and form of substances present

On October 12, 1979, a confidential informant revealed to the U.S. EPA Region VII the locations of this site and of other sites. In the weeks that followed, a reconnaisance team visited the sites and conducted interviews with 25 people, including some people who previously worked for NEPACCO, some people who were eyewitnesses to the disposal of the drummed wastes, and some people who participated in the waste disposal. Interviewees indicated that the material at

300.63(a) discovery

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[1] All measurements reported in this document are indicated in both English and Metric units, respectively, e.g., gallons (liters; l); feet (meters; m).

the Denney Farm site included reworked liquor or recrop material from which no additional hexachlorophene could be extracted.

The U.S. EPA initiated a preliminary excavation and sampling investigation in April 1980. Dioxin concentrations as high as 319 ppm (mg/1) were shown in the analysis of composite drum samples.[2] The EPA concluded that an immediate response was necessary to protect human health and the environment. The disposal trench was capped with an impermeable membrane and surface water was diverted from the site. Also, weekly monitoring of 14 water wells and one spring was begun to assure that groundwater at points surrounding the site was not contaminated. Additionally, an engineering study was undertaken to determine the best techniques for dealing with the waste.

300.65(b)(7)
barrier to deter
spread or release

A complaint, naming several defendants for contributing to the disposal of chemical wastes, was filed by the EPA on August 1, 1980 in the U.S. District Court for the Western District of Missouri. The primary concern in the suit was the imminent hazard to persons, to wildlife, and to the environment in the vicinity of the Denney Farm site. A consent decree was approved and entered September 12, 1980, whereby one of the defendants, Syntex Agribusiness, Inc., assumed responsibility for providing for ultimate destruction or safe permanent disposal of the wastes and the contaminated soil at the site. Syntex received formal approval from the EPA for an extensive plan for the cleanup of the Denney Farm site and began cleanup of the trench in June 1981. Although the liability for production or disposal practices that caused the problem was denied by Syntex, the corporation nonetheless accepted the responsibility for cleanup measures.

300.68(c)
judicial
process

300.61(c)(2)
private party
cleanup

Background

NEPACCO in Verona, Missouri, manufactured hexachlorophene, a chemical used as a bactericide and bacteriostat, from April 1970 until January 1972, when the chemical was banned by the Food and Drug Administration (FDA). During this time, NEPACCO leased a portion

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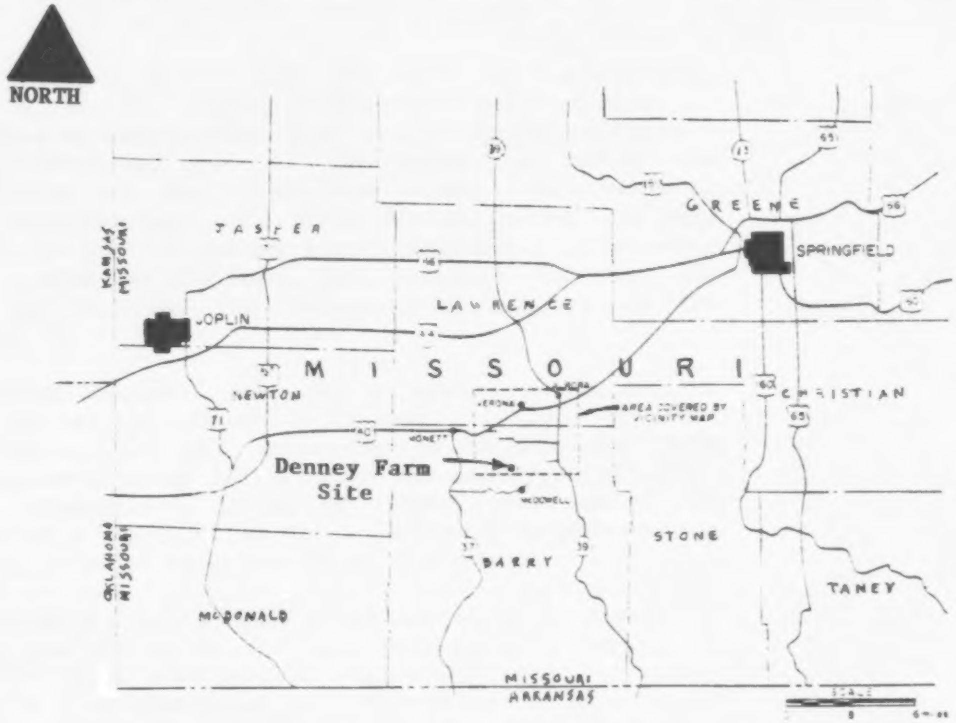
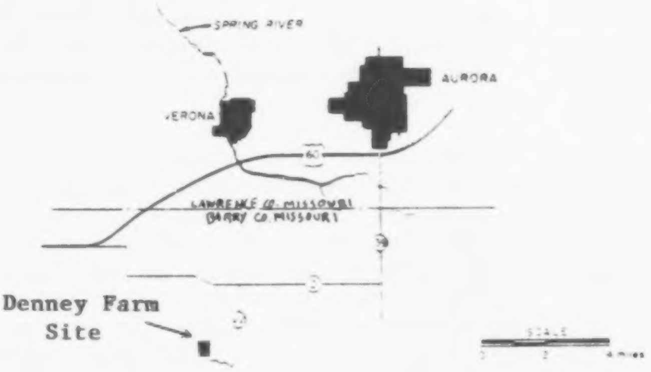
[2] For the purpose of this report, all referenced TCDD and dioxin concentrations are assumed to have been generated from analysis assumption may not be true for all cases.



LOCATION MAP



VICINITY MAP

Figure 1. Location and Vicinity Map of Denney Farm Site in Southwestern Missouri

Source: Syntex Agribusiness, Inc. 1980

of a plant in Verona that was owned by Hoffman-Taff, Inc. In the late 1960's, Hoffman-Taff had used this same area to manufacture agent orange for the military until diminished use of the herbicide forced the curtailment of the production line. Manufacturing facilities remained idle until NEPACCO leased the area for the purpose of making hexachlorophene. In December 1969, Syntex Agribusiness, Inc. purchased Hoffman-Taff, Inc. and acquired the Verona plant subject to the NEPACCO lease.

Trichlorophenol was used to make a pharmaceutical grade of hexachlorophene. To make this type of hexachlorophene, it was necessary to purify the triCHlorophenol, using distillation and condensation equipment. Impurities, including dioxin, remained at the bottom of a still, from which they were transferred to holding tanks or drums and later discarded.

Waste materials were disposed of at a number of sites, one of which was the James Denney Farm. In response to a confidential telephone call, a reconnaisance team consisting of personnel from the offices of U.S. EPA Region VII's Air and Hazardous Materials Branch and Surveillance and Analysis Division, and the Missouri Department of Natural Resources investigated the site and conducted interviews with 25 people. Coupled with EPA's knowledge of previous events related to the handling and the disposal of wastes from NEPACCO's operation, it was assumed for safety reasons that the wastes contained 2,3,7,8-tetrachlorodibenzoparadioxin (TCDD).

300.64(a)(1) evaluation of hazard

This isomer of dioxin is one of the most toxic chemicals ever synthesized, with toxic dosages for some animals being on the order of micrograms per kilogram. Research on the effects of low-level exposure to dioxin has revealed that it can lead to delayed and varied reactions. Dioxin is believed to cause chloracne, teratoma, spontaneous abortions, stillbirths, sterility, carcinomas, and mutations. (E&E 1980).

300.68(e)(2)(i) (C) hazardous properties of substance

Based on information gathered in the initial investigation, it was originally estimated that between 30 and 150 55-gallon (208-1), metal, caustic drums were buried at the site. During the subsequent field investigative activities conducted at the site, the number of buried drums was more precisely estimated to be between 80 and 90. The EPA opened the trench and exposed 13 barrels and sampled 8 of these and their associated soils at the site in an investigation that began in April 1980. The purpose of this investigation was to "document the presence or absence of dioxin and its precursors and/or degradation products" at the site. The composite samples analyzed showed concentrations of dioxin in the drums of up to 319 ppm (mg/l).

300.66(c)(2)(ii)
assessing type of
hazardous substance

Prior to the sampling effort, the site was cleared and secured by erecting a 9-foot (2.7-m) high security fence. Bore holes for sampling were drilled around the trench, and three drinking water wells were sampled. No dioxin was found in the drinking water samples, and all but two soil samples were free of contaminants.

300.65(b)(3)
security fencing

Subsequent sampling efforts by EPA's Field Investigation Team (FIT) and others demonstrated that there was minimal lateral migration of the contaminants outside of the trench (see Description of Contamination section). Physical characteristics of the subsurface were examined using testing methods, including electromagnetic conductivity, resistivity, seismic refraction, ground-penetrating radar, and metal detection. The primary concern over the drums of disposed wastes at this site was the high toxicity of dioxin. Another matter of concern was the area's karst topography, characterized by sinkholes, underground caves, and broken rock, all of which increase the potential for groundwater contamination.

300.68(e)(2)(ii)
extent of migration

300.67(c)(4)
surface soil
hazard

The population within a one-mile (2 km) radius is estimated at 76 persons, although census figures were not available to confirm this. Nearby towns include Aurora (population 6,200) 8 miles (13 km) to the northeast, Monett (population 6,000) 7 miles (11 km) to the northwest, and Verona (population 680) 7 miles (11 km) to the north. Prior to the September 1980 consent decree, EPA was regularly sampling and analyzing groundwater from nearby wells to determine the safety of the drinking water in the area. The consent decree shifted these water monitoring responsibilities from the EPA to Syntex. In October 1980, Syntex took over the responsibility for water sampling and analysis in accordance with a monitoring plan it submitted to EPA on September 24, 1980. No TCDD contamination has been detected in the off-site monitored wells to date.

300.68(e)(2)(i)
(A) population at
risk

On August 2, 1980, the EPA Administrator announced the agreement between the U.S. EPA and Syntex Agribusiness, Inc., for a program to ensure the removal and the safe disposal of the hazardous wastes at the Denney Farm site.

300.68(c)
responsible
party cleanup

The consent agreement required Syntex to submit a plan of action to the EPA, and upon approval, to implement and to complete the plan on or before the passage of five years from the date a final plan was approved. In addition, the consent agreement stipulated that Syntex would reimburse the EPA the amount of $100,000 for the investigative work it conducted prior to the agreement between the two parties. Formal approval of the Denney Farm Site Plan was granted by the EPA on February 25, 1981.

Synopsis of Site Response

The Denney Farm Site Plan developed by Syntex was designed to protect the safety and the welfare of the community, the workers associated with the site, and the environment. After a review of site and waste characteristics, the plan described site responses, including preparation, excavation, and handling of materials and site closure. Also included in the plan were methods to be used for detoxification of the contaminants. Liquid wastes were to be treated by photolysis, and all contaminated soils were to be treated by either microbial degradation, extraction methods, or some other technical approach as approved by EPA.

Drums were excavated and removed from the trench beginning June 15, 1981, and the last of an estimated 80 to 90 drums was removed on July 16. Further removal of soils, sampling and analysis of soils from trench sides, and bottom and decontamination procedures continued in the following weeks. Samples of residual materials left on the trench walls showed the highest concentrations of dioxin in the western end of the trench at levels reaching 467 ppb (ug/kg). Following excavation and sampling of the wastes and the soils, it was determined that the treatment methods outlined in the Site Plan were not feasible as final solutions. No final decision could be made at this time regarding a suitable alternative as a final remedy. Therefore, visibly contaminated soils and solid wastes were temporarily stored in overpacks and

300.68(e)(1)(iv)
hazardous substances in drums

non-visibly contaminated soils were placed in a Microbial Degradation Basin (MDB). Closure of the trench was approved by the EPA, after considering factors such as geology and proximity to population centers. Capping of the trench was completed December 11, 1981.

300.70(b)(2)
(iii)(A)(3)
supported growth
biological reactors

At the time of this writing, the selection of a method for the ultimate disposal of TCDD-contaminated wastes at the Denney Farm site had not yet been finalized. However, the decision had been made to bring the EPA, Office of Research and Development's (ORD) mobile incinerator system on-site to run trial burn tests to determine its applicability for destroying TCDD-contaminated wastes. After this decision was made, EPA ORD contracted with a specialized technical firm to operate the system and to run the trial burns. A final permit application was submitted by the contractor to EPA in June 1984. A permit was issued for use of the mobile incinerator at the Denney Farm site on October 19, 1984, effective November 18, 1984. At the time of this writing the burn tests had been completed and the actual burning of wastes was scheduled to begin in late June 1985. Because the site is considered an interim status facility under Federal and state regulations, once wastes are managed, a closure plan will be completed.

SITE DESCRIPTION

Surface Characteristics

The Denney Farm site is located within the Springfield Plateau Physiographic Region. Valley and ridge erosion typifies the geomorphology of the region. Orientations of fractures and solution enlargements in the limestone bedrock underlying the area largely control the location of valleys (Canonie/D'Appolonia 1981). Ridges are commonly capped by red clay soils with chert fragments common in soils on the steeper portions of hills.

The Denney Farm site is located approximately 7 miles (11 km) south of Verona in Barry County, Missouri (Figure 1). The farm lies on the west side of County Road VV, south of Pleasant Ridge, and south-southeast of Calton Creek (Figure 2). The disposal trench is situated on a ridge top bounded by Calton Creek on the north and west and by the Little Flat Creek to the south. Maximum elevation of the ridge is approximately

1,460 feet (445 m), with the surveyed trench site elevation ranging from 1,433 to 1,438 feet (436.7 to 438.3 m) (Canonie/D'Appolonia 1981). Besides con-trolling valley formations, the limestone bedrock under-lying much of the area has been dissolved in certain areas with sinkholes, and losing or influent stream segments are common.

300.68(e)(2)(i)
(E) climate

The local climate is characterized by data collected at the closest information station, the Springfield, Missouri Municipal Airport. Normal temperatures during the 19-year monitoring period range from a monthly low in January of 33.6° F (-13.3° C) to a monthly high in July of 78.8° F (11.7°C). The yearly average temperature for the period is 56.5°F (-0.6°C) (E&E 1980).

Precipitation averages 41.08 inches (104.3 cm) per year. The period of highest rainfall occurs in May when 5.28 inches (13.4 cm) per month is the average. January tends to be the driest month, averaging 1.96 inches (4.97 cm) of precipitation. The annual average for snow and sleet precipitation is 13.0 inches (33 cm), with a high of 3.4 inches (8.6 cm) in February and March.

Prevailing wind direction in the area is out of the south-southeast year round. Windspeeds are relatively constant throughout the year, with a mean speed of 11.6 miles per hour (18.66 km/hr) and a high monthly average of 15 mile per hour (24 km/hr) in March. Historically, the area around Denney Farm has a high incidence of tornado touchdowns. The average tornado damage area has been estimated to be about 2 square miles (5 km^2).

The recorded incidence of tornadoes in a 15,000-square-mile (38,850-km^2) area around Denney Farm is 111 over a 46-year period (1916-1961).

Slopes along the hillsides adjacent to the Denney Farm trench site are from 5 to 20 percent. The soils of the area are referred to as the Baxter-Bodine soil association. Baxter soils occur on the ridge tops and Bodine soils occur on the steep areas along hillsides. The ridge tops are generally capped with a thin, 3-foot (0.9-m) veneer of loess, an aeolian-deposited buff silt. The loess is underlain by a red kaolinitic silty

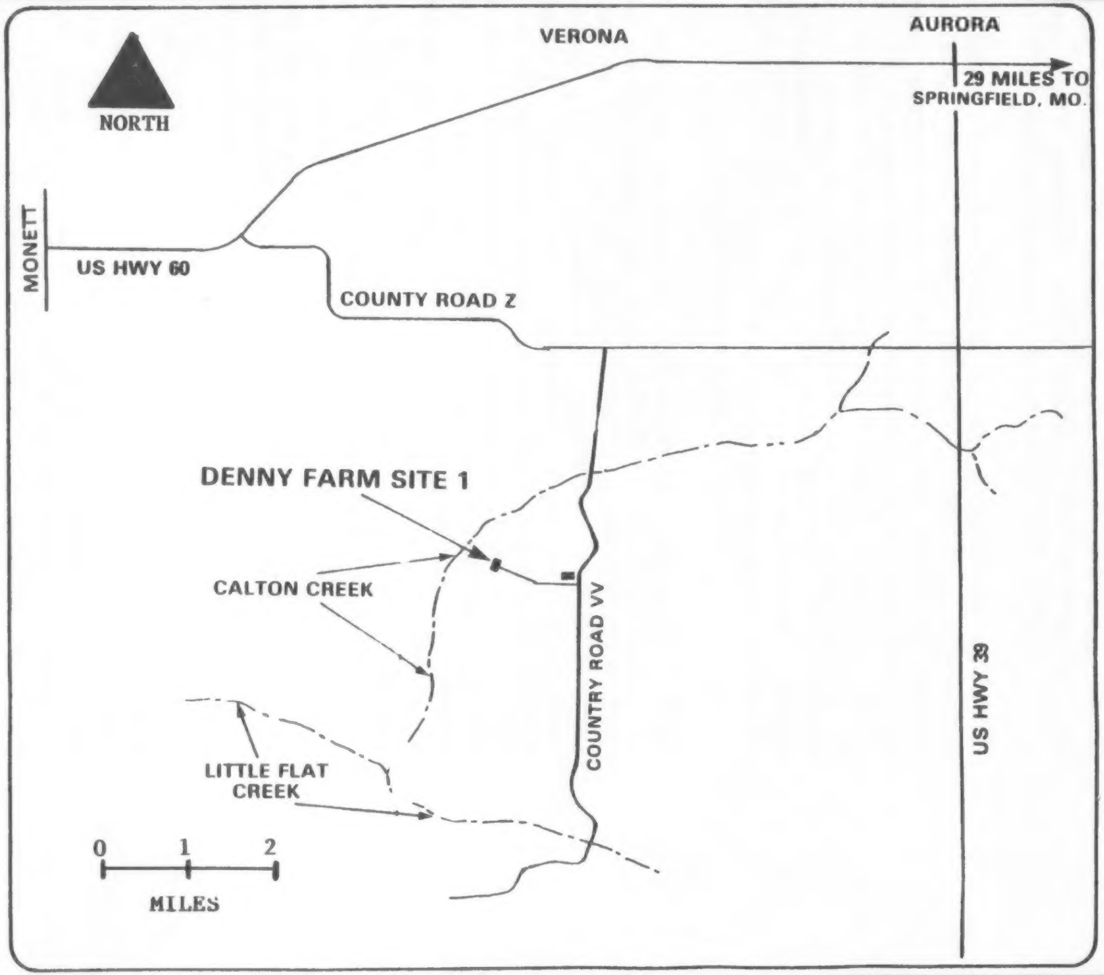


Figure 2. Location of Denney Farm Site with Respect to Rural Roads in the Area

Source: E&E 1980

clay and silt with numerous angular chert fragments. The composition of the kaolinitic clay silt has been determined by soil boring analysis at the site to include up to 74 percent clay (Canonie/D'Appolonia 1981). Soil development along hillsides has been minimal because of colluvial erosional processes, with valley soils commonly being thick, complex mixtures of stratified and non-stratified material (E&E 1980).

Denney Farm is located in the relatively sparsely populated, rural Barry County. Aurora, Missouri, located approximately 7 miles (11 km) north of Denney Farm, is the most densely populated area near the site with 6,200 residents according to 1980 figures. Just west of Aurora is Verona, Missouri, with a population of 680 residents. Both towns are located in Lawrence County, which borders Barry County to the north. There are a number of residents with private water wells in the rural area around Denney Farm.

The site is located very near the topographic high point of the ridge and about 150 feet (45.7 m) higher in elevation than Calton Creek. Surface waters drain east from the site to a swale and subsequent tributary. The tributary drains west-northwest into Calton Creek. Calton Creek flows south to its confluence with Little Flat Creek approximately 2.5 miles (4.02 m) south of the site. Little Flat Creek flows east-southeast to the James River and then south to Table Rock Lake, a reservoir on the White River. Little surface flow has been noted in the swales and tributaries draining the Denney Farm site, with permeable soils and bedrock along hillsides allowing rapid infiltration. The flow of Calton Creek is controlled by jointing in the underlying Reed Spings Formation and segments of the stream have no flow or are influent.

Hydrogeology

300.68(e)(2)(i)
(D)
hydrogeologic
factors

Denney Farm is situated on the Springfield Plateau on the edge of the Ozark Mountains' foothills. The Denney Farm area is underlain by the Mississippian Age Reed Springs Formation. The Reed Springs is a gray to bluish-gray limestone with alternating bands of chert and a thickness ranging up to 225 feet (68.5 m) in the southernmost portions of Missouri. An argillaceous limestone, containing interbedded chert belonging to the

Compton Formation, underlies the Reed Springs Formation. This limestone unit ranges from 20 to 30 feet (6.1 to 9.1 m) in thickness. Bedrock in the Denney Farm area is relatively flat-lying, with dissolution of the carbonates providing a karst topography. Drainage patterns of Calton Creek and other streams in the area show evidence of being fractured or joint-controlled with angular offsets in stream patterns. Fracture density and orientation and subsequent degree of dissolution vary in the area, making prediction of groundwater flow direction and rate difficult (E&E 1980). Figure 3 shows the effect of variable groundwater flow conditions on surface waters in the Denney Farm area. Segments of streams designated as gaining or effluent give way to segments where surface waters become losing or influent (E&E 1980). The areas designated as losing segments of the stream are recharge areas to the groundwater within the Reed Springs Formation, and reflect variable hydraulic head conditions in the water table associated with Calton Creek.

In immediate proximity to the Denney Farm site, two groundwater discharge points have been documented, a spring-fed pond approximately 1000 feet (305 m) west of the trench site and a small spring that discharges into Calton Creek west of the site (see Figure 3). The spring as characterized by a geologic consultant retained by Syntex as having an estimated flow of 2-3 cubic feet per second (0.05 - 0.08 m^3/sec), under drought conditions at the time of its discovery (Bowers 1980). Hydraulic properties of the Reed Springs Formation have been generalized as 10 percent porosity, a hydraulic conductivity of 1.5 x 10^{-2} ft/sec (4.72 x 10^{-1} cm/sec), and a hydraulic gradient of about 3 percent (E&E 1980). Dip of the bedrock is generally toward the east, indicating that discharge points west of the site are controlled by topographic truncation.

Soil thickness underlying the Denney Farm site varies considerably. Three borings taken by Syntex's contractor revealed depths to bedrock of 13, 19, and 38 feet (3.9, 5.8 and 12 m). Geophysical investigations across the site indicated that soil thickness was 15 feet (4.5 m) or greater and that a suggested depression in the bedrock profile across the ridge possibly accounted for greater accumulation of soils. Seismic and resistivity methods indicated that the residual

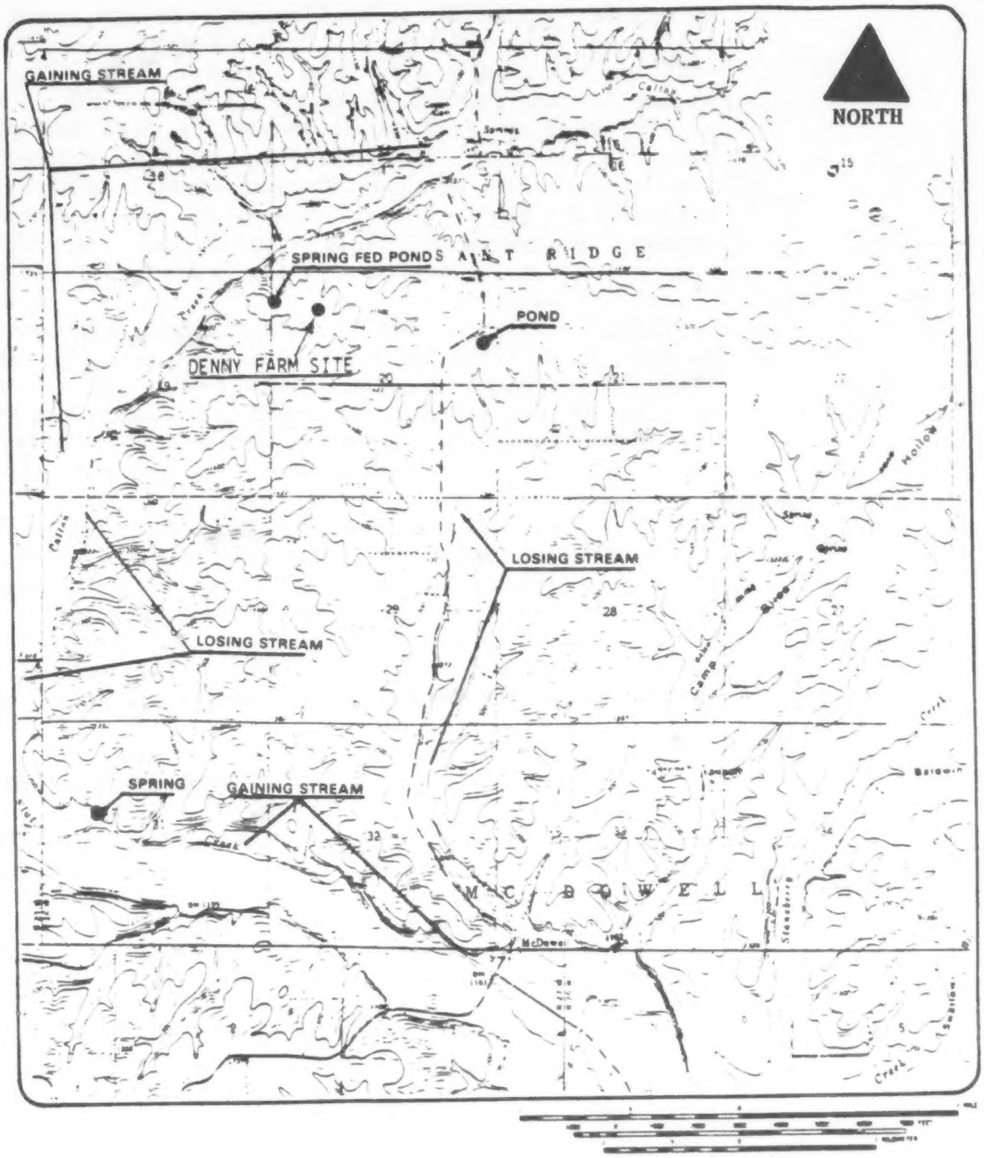


Figure 3. Effect of Karst Bedrock on Streams in the Denney Farm Site Area

Source: E&E 1980

clays, which are about 11 to 16 feet (3.3 to 4.9 m) thick along the west fence line at the site, thicken to 29 to 37 feet (8.8 to 11 m) along the east fence line (E&E 1980). An initial soil boring program was conducted by EPA Region VII in April 1980 to collect and to analyze the sail to depths of 10 feet or less (Figure 4). Bedrock was not encountered in the areas of these borings. The fine-grained fraction of soils taken from the borings was determined using X-ray diffraction methods as containing fine (clay-sized) quartz kaolinite/chlorite and geothite minerals.

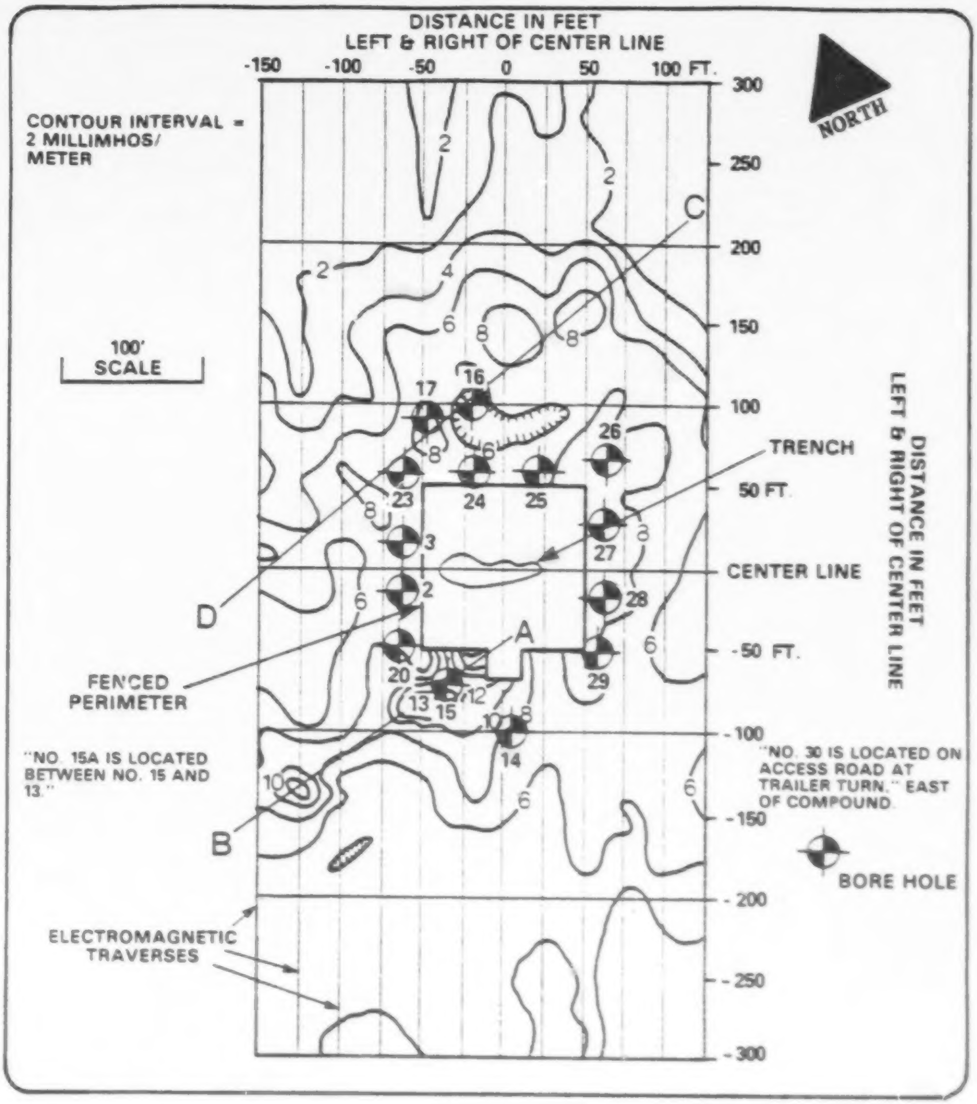
Upon the completion of the trench excavation, several geologists visually examined soils at the trench bottom and the sidewalls. Geologists from the Missouri Department of Natural Resources and Syntex, as well as EPA Region VII personnel, subjectively concluded that the soils observed were impermeable.

The water table is approximately 114 feet (34.7 m) below the site, based on a typical hydraulic gradient of 3 percent and the base flow level of Calton Creek (E&E 1980). Borings drilled to depths of 60 feet (18 m) below the existing grade of the trench area did not encounter the water table and also indicated that no perched water exists in the immediate vicinity of the ridge.

WASTE DISPOSAL HISTORY

NEPACCO, incorporated in 1966, began production of a pharmaceutical grade of hexachlorophene in April 1970. Hexachlorophene (HCP), a chemical which was used as a bactericide and bacteriostat until it was banned by the FDA, is derived by the condensation of 3,4,5-trichlorophenol with formaldehyde in the presence of sulfuric acid. The production of trichlorophenol, a compound derived from tetrachlorobenzene, produces levels of TCDD which may vary from batch to batch depending on conditions of the reaction. NEPACCO operations included a distillation step for the purification of the trichlorophenol and contaminants, such as TCDD, that remained in the still bottoms. According to former NEPACCO personnel, these wastes were allowed to collect during operations and were generally removed on a weekly basis. On the basis of reports supplied by Syntex, NEPACCO ran 328 batches of trichlorophenol between April 1970 and January 1972.

300.64(a)(2)
identification
of source of
release



"NO. 15A IS LOCATED BETWEEN NO. 15 AND 13."

"NO. 30 IS LOCATED ON ACCESS ROAD AT TRAILER TURN." EAST OF COMPOUND.

Figure 4. Soil Boring Locations and Geophysical Survey Lines at the Denney Farm Site

Source: E&E 1980

The Denney Farm site contains only a small fraction of the dioxin-contaminated wastes produced by these operations; other disposal sites receiving these wastes have been discovered both in and outside of the State.

Disposal methods at Denney Farm involved a trench that was dug out by a crawler tractor with a backhoe attachment. The trench measured about 60 feet (18 m) long, between 10 and 13 feet (3 to 4 m) wide, and generally less than 6 feet (1.8 m) deep. Wastes contained in 55-gallon (208-l) drums were dumped out of the back of a dump-truck and left where they fell. They were then covered with 1 to 3 feet (0.3 to 0.9 m) of soil. According to an eyewitness, the drums were in marginal condition at the time of burial.

DESCRIPTION OF CONTAMINATION

In October 1979, EPA Region VII was informed that wastes of defunct NEPACCO were buried at a farm south of Verona, Missouri. Shortly thereafter, a field team of EPA Region VII personnel, in cooperation with the Missouri Department of Natural Resources, conducted an intensive two-week investigation. The investigation identified three disposal sites, one of which was the Denney Farm site. During the investigation, the field team discovered a depression at Denney Farm covering an area of approximately 10 by 53 feet (3 by 16 m) with its length trending east-west. Interviews with former NEPACCO employees indicated that during June 1971, between 30 and 150 55-gallon (208-l) drums had been disposed of in the trench at Denney Farm. Drums were dumped in the trench, covered with 1 to 3 feet (0.3 to 0.9 m) of soil, and no underlining or capping of the trench had taken place. The drums were in marginal condition at the time of burial, and according to one eyewitness, at least one of the drums was leaking.

300.64(a)
preliminary
assessment

The chemical waste of primary concern was dioxin (2,3,7,8-tetrachlorodibenzo-para dioxin or TCDD), a trace contaminant formed in the production of 2,4,5-trichlorophenol (TCP), which was an intermediate in the production of hexachlorophene by NEPACCO. Because of this concern and the fact that NEPACCO wastes were associated with the deaths of numerous animals when used directly or comingled with wastes oil for dust control at local horse arenas in central and eastern Missouri 1971, a security fence was placed around the trench after its discovery to prevent entry to the disposal site. During the next several months, EPA developed a site investigation plan and conducted sampling of the site. Upon the confirmation of the presence of TCDD, EPA conducted operations to assess hydrogeologic conditions at the site and to identify the number of drums buried and the trench boundaries through geophysical investigations. These activities included sampling of surface waters in Calton Creek, groundwater wells of nearby residents, and soils from borings taken around the disposal area, as well as geophysical studies employing ground-penetrating radar, magnetometers, metal detectors, and resistivity and electromagnetic conductivity surveys.

Based on magnetometer data, the maximum length of the trench was estimated at 65 feet (20 m), and apparently more drums were buried at the west end than at the east end of the trench. Trench depth was estimated at 6 to 8 feet (1.8 to 2.4 m). Geophysical investigations indicated that a maximum of 145 drums were buried in the trench. Depth to bedrock was estimated at 15 feet (5.4 m) or greater, indicating that the trench was not in contact with the underlying limestone unit.

In order to determine if TCDD-contaminated materials were present in the trench, EPA partially excavated the trench in April 1980. Thirteen drums were unearthed and samples were collected from eight of the drums. The condition of the drums varied, with one drum being crushed and empty. Only one drum was reported to be full, three others were approximately three-quarters full, and the remaining drums were half full or less. Upon the completion of sampling, the trench was backfilled with the overburden that had been removed. The trench was then covered with an impermeable temporary cap to minimize surface water infiltration. The cap consisted of a heavy plastic sheet that with a layer of sand and a second plastic sheet that was then covered with a layer of gravel. This temporary cap was designed to prevent any infiltration into the trench, as well as to limit the exposure of cap materials above the bottom plastic sheet to contaminated materials. Berms were constructed around the west and south sides of the cap to divert surface runoff around the trench and sampling was continued in wells, ponds, and streams surrounding the site.

Samples were taken from eight of the thirteen drums uncovered. Samples from four of the drums were visually similar with a black, oily appearance. These four samples were composited and analytical test results showed a TCDD concentration of 319 ppm (mg/l). A composite of sampled material from the other four drums was analyzed and indicated a TCDD concentration of 1.4 ppb (ug/kg). This composite was also analyzed by EPA for priority pollutants. Trace levels of tetrachlorobenzene, toluene, xylene, and C_9H_{12} isomers, as well as 2,4,5-trichlorophenol, at a concentration of 1.9 ppb (ug/kg), were found.

Discrete soil samples were also taken from the soils in the trench and composited for analyses. These samples were selected from areas within the trench where oily, black material appeared. Analytical results of the composited soils samples showed a TCDD concentration of 92 ppb (ug/kg).

Sample analyses were also performed on 12 bore hole soil samples collected prior to excavation from the estimated trench perimeter. Table 1 summarizes the EPA test results on these samples. The estimated distance of the bore holes from the trench was 5 to 10 feet (1.5 to 3 m), although bore hole number 1 was probably drilled into the west end of the trench. Samples were composited from a 28-inch (71-cm) column of soil taken from the bottom of the borings. Boring depths ranged from 5 to 10 feet (1.5 to 3 m). The test results indicated that no lateral movement of TCDD contamination from the trench could be confirmed at a detection limit of 0.0003 ppb (ug/kg).

Weekly monitoring of 14 local resident water wells and the surface waters of Calton Creek was conducted beginning in April 1980 to identify any groundwater contaminant transport from the Denney Farm site. The mobility of TCDD through soil is considered low based on tests and literature. This lack of mobility is considered to be caused by the extremely low water solubility of TCDD at 0.2 ppb (ug/l) and its tenacious binding affinity, especially in clay or organic rich soils that have a high ion-exchange capacity. Although analysis of water well samples showed no TCDD present, these findings did not resolve the issue of potential groundwater contaminant transport because there was potential for vertical movement of contaminants downward toward the groundwater. The weekly monitoring program was continued with samples being analyzed for TCP, since TCP has a greater water solubility than any other organic pollutants found in the trench. No TCP contamination was found in any of the groundwater or surface water samples.

EPA also collected and analyzed sediment samples and fish tissue in June 1980. Sediment samples were taken from drainage areas feeding Table Rock Lake, Calton Creek, Little Flat Creek and James River. Fish samples were taken from the two drainage areas to Table Rock Lake. The tendency of TCDD to become concentrated in fish tissue suggested that fish sampling would be a good indicator of environmental contamination. Fish samples were analyzed for TCP and TCDD, while sediment samples were analyzed for TCP only. Analytical results indicated the no TCP or TCDD was found in any of these samples.

Based on the pre-excavation sampling and analysis program, the EPA found no evidence of TCDD-contaminated soil beyond 5 to 10 feet (2-4 m) of the trench perimeter, or contaminant transport through the hydrologic systems in the site area. Soil analysis conducted on samples collected from the tranch after it was completely excavated, however, indicated that high TCDD levels remained in the trench even after the trench contents and about 140 yd^3 (117 m^3) of soil had been removed. These findings led EPA to contend that migration of the contaminants had begun and would have been promoted by existing organic solvents, the hydraulic head produced by the trench contents and precipitation events, had the trench not been excavated and its contents removed (see Extent of Response Section).

PLANNING THE SITE RESPONSE

Initiation of Site Response

The preliminary assessment of the Denney Farm site was conducted by personnel of the EPA Region VII office and the Missouri Department of Natural Resources (MDNR) in September 1979. The excavation and sampling effort

300.64(a)
preliminary
assessment

TABLE 1. EPA COMPOSITE SOIL SAMPLE ANALYSES, APRIL 22-26, 1980

Bore Hole Number	TCDD (mg/kg)	TCP (mg/kg)	Di - n butyl (mg/kg)	Bis - (2-ethylhexyl) (mg/kg)	Di - n - Octyl (mg/kg)
1 *	0.004	63	ND **	2.2	ND
2	ND	ND	0.3	3.9	ND
3	ND	ND	ND	2.9	ND
4	ND	1	0.37	14	ND
5	ND	ND	0.3	2.2	ND
6	ND	ND	ND	3.5	ND
7	ND	ND	0.36	130	0.66
8	ND	ND	0.42	180	ND
9	ND	ND	0.36	560	ND
10	ND	ND	ND	97	ND
11	ND	ND	ND	2100	ND
12	ND	1	1	2200	ND
Detection Limit	0.0003	0.2		0.3	0.5

* This bore hole probably was drilled into the west end of the disposal trench. This is supported by the fact that this was the only bore hole in which water was encountered - all other bore holes were dry and basically contained the same type of soil/small rock mix.

** Not Detected.

Source: U.S. EPA 1980e

that followed in April 1980 led to an "immediate response" in which, among other actions, the site was covered with an impermeable membrane and surface waters were diverted from the site.

300.65(b)(7)
barrier to deter
spread or release

The equivalent of a Remedial Investigation and Feasibility Study is contained in the document entitled "Technical Study and Remedial Action for Denney Farm Site 1, Aurora, Missouri." The final report was submitted to the EPA on September 15, 1980 by the FIT contractor (E&E 1980).

300.66(a)
assessment for
further action

The Denney Farm Site Plan was submitted to the EPA by Syntex 45 days after the September 1980 FIT report was submitted. This plan included a review of all of the sampling data and information on the properties of the wastes buried at the site. Detailed references to the efficacy of microbial degradation and photolysis were also given in this report. From this information, the plan of action was developed. Design specifications, safety procedures, contingency plans, monitoring facilities, and methods and procedures were all detailed in this document which, after EPA review, received approval, in February 1981.

Selection of Response Technology

The selection of response activities and technologies at the Denney Farm site occurred before definite protocol was available from the then emerging Superfund (CERCLA) program, such as the procedures outlined in the National Contingency Plan. The selection of specific technologies and the decision to clean up the site was carried out expeditiously by the EPA and MDNR, given the highly toxic nature of the contaminants present. Also, on September 12, 1980, while denying knowledge or responsibility for NEPACCO's waste disposal practices, Syntex entered into a consent decree to develop and to implement a remedial action plan.

The ultimate objective of the remediation effort as stated in the consent decree was as follows:

> "The mutual objective of the Parties to this Decree is the formulation, implementation, and monitoring of results thereof, of the best practicable plan for removal and permanent disposal by containment, destruction or other means (disposal) of all

> hazardous wastes located in and immediately adjacent to the Disposal Trench which, according to the best available scientific judgment at the time of presentation of the plan contemplated in Part III. B. of this Decree, pose an imminent and substantial endangerment to human health or the environment."

300.68(e)(1)
initial measures

The plan referred to as contemplated in Part III. B. of the decree was the plan to excavate the wastes, to implement remedial technologies to treat, destroy, or dispose of the waste, and to monitor the remediation. Also, the decree stated that disposal would be completed on or before the passage of five years from the date a final plan was approved.

Syntex developed a remedial action plan outlining the procedures to be used for cleaning up the Denney Farm site. Federal and State agencies commented on the plan and, upon completion of modifications, the plan was approved on February 25, 1981. In April 1981, remedial work began at the site with construction of support buildings. The proposed remedial actions called for the removal of the temporary cap, the excavation of the trench and waste materials, and the treatment or disposal of these materials.

The EPA directed Syntex to proceed with the plan, which included:

- Site preparation, such as construction and staging of buildings and auxillary equipment
- Trench excavation and waste exhumation
- Use of a microbiological degradation basins (MDB) to detoxify any non-visible contaminated soil removed from the trench
- Use of 85-gallon (322-l) drum overpacks to hold visibly contaminated soils and solid wastes
- Use of a temporary on-site storage structure for on-site containment of drum overpacks until decisions about disposition of the materials are made.

The full range of remediation techniques considered by Syntex and the EPA included:

300.68(g)
development of
alternatives

- Trench excavation
- Controlled disposal in a designated approved facility
- Deep well injection
- In-site containment by use of impermeable barriers and capping
- Ultraviolet photolysis
- Chemical solidification
- Microbiological treatment
- Incineration - land-based and at sea
- Encapsulation
- Carbon treatment
- Physical solidification
- On-site storage.

Table 2 summarizes these technologies and briefly indicates the rationale for either their acceptance, rejection, or undecided status.

The majority of approved commercial disposal facilities refused to accept the TCDD-contaminated waste. At the point in time when disposal at a RCRA regulated facility was considered, at least one facility did agree to consider accepting the waste. However, based on political and public relation aspects and shipment complexities, however, the option of disposal in a permitted facility was eliminated from consideration.

Although disposal using deep well injection had been employed at various locations throughout the United States, no facilities specifically permitted for handling dioxins were identified. This lack of an injection well facility for dioxins eliminated this potential disposal method from further consideration.

Capping or sealing the trench and placing an impermeable barrier, such as a slurry wall, around the trench was considered, since these technologies would eliminate airborne contamination and minimize infiltration and subsequent off-site migration of leachate. However, this containment option was considered infeasible, because subsurface conditions below the trench floor were unknown and the risk of disturbing the structure and the stability of the limestone bedrock below the trench and increasing potential contaminant migration was too high.

Ultraviolet photolysis of TCDD requires dissolution in a light-transmitting liquid film, an organic hydrogen donor, and irradiation with ultraviolet light. Two factors limited the viability of treating the Denney Farm waste through ultraviolet photolysis. Treatment is restricted to liquid wastes and the solid wastes, sludges, and contaminated soils at Denney Farm could not be effectively treated. Also, TCDD is not completely eliminated by the process, as residual concentrations up to 500 ppb (ug/kg) are found to remain after the treatment. Because such a small volume of the waste at Denney Farm was in liquid form, the photolysis treatment was unacceptable.

Chemical solidification was not considered as a viable treatment either since the acute toxicity of TCDD posed too great a threat in terms of long-term stabilization of the wastes, and prevention of eventual leaching into the environment could not be guaranteed.

The physical treatment alternatives of encapsulation, carbon treatment, and physical solidification were eliminated from consideration for a variety of reasons. Encapsulation had not been demonstrated under actual field conditions. The process involved physically enclosing wastes in a synthetic structure, but the necessary materials, the capital equipment, and the energy costs were considered prohibitive. Carbon treatment was simply an inappropriate alternative given the viscous, tarry nature of the still bottoms, the nonhomogeneity of other wastes at the site, and the fact that it would only reduce the bulk volume of TCDD contaminated waste and not actually destroy the wastes. The potential problem of interaction of the organic contents of the wastes at Denney Farm with solidifying agents ruled this technology out as an alternative.

TABLE 2. REMEDIATION TECHNIQUES CONSIDERED FOR THE DENNEY FARM SITE, AURORA, MISSOURI

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ ACCEPTANCE	NCP REFERENCES
Disposal in designated facility (R)	Burial in underlined controlled disposal facility	Refusal of wastes by numerous facilities and unacceptable public relations aspects	300.70(c)(1)(ii) off-site transport; capacity to manage hazardous wastes
Deep well injection (R)	Inject wastes underground in unutilizable and isolated zone	No facilities permitted to handle dioxin	
In-situ containment (R)	Use of impermeable barrier (slurry) walls and cap	Environmental setting, with limestone dissolution cavities in subsurface, was unacceptable	300.70(b)(1)(A)(1) slurry 300.70(b)(1)(ii)(A) surface seals
Ultraviolet photolysis (R)	Ultraviolet light degradation of TCDD	Off-site transportation sensivity; treatment only applicable to liquid waste--Denney Farm waste highly non-homogenous method	300.70(c) off-site transport 300.70(b)(2) direct waste waste treatment
Chemical solidification (R)	Use of chemical agents to stabilize wastes	Could not guarantee long-term stabilization	300.70(b)(2)(iii)(C) solidification

(continued)

TABLE 2. (continued)

RESPONSE TECHNOLOGY ALTERNATIVE	**DESCRIPTION**	**RATIONALE FOR REJECTION/ ACCEPTANCE**	**NCP REFERENCES**
Encapsulation (R)	Encapsulation of waste in synthetic encasement	Materials, equipment, and energy costs prohibitive, and not ultimate destruction	
Carbon treatment (R)	Filtration and Absorption/ Adsorption of wastes	Tarry, viscous condition of wastes not treatable in this manner	300.70(b)(2)(ii) (B) chemical methods
Physical solidification (R)	Use of solidifying agents to physically immobilize wastes	Potential interaction problem with organic constituents	300.70(b)(2)(iii) (C) solidification
Microbiological degradation (A)	Use of microbes to biologically decrease contaminant levels in non-visibly contaminated soils	Research studies have shown that large quantities of soil containing low levels of TCDD can be successfully detoxified using suitable microbes and controlling environmental conditions	300.70(b)(2)(iii) (E)(3) microbiological degradation
On-site storage (A)	Temporary containment	Allowed for excavation and safe/ secure storage until alternative remedial action selected	
Incineration (U)	Ultimate destruction through burning or incinerating wastes	Successful demonstration at sea on MT Vulcanus and only available technology given site and waste characteristics	

R = Rejected
A = Accepted
U = Undecided

The remaining remedial action alternatives were incorporated into the Site Plan as temporary measures for containment of excavated wastes and contaminated soils on-site. These actions included: on-site storage of visibly contaminated materials in 85-gallon (322-l) drum overpacks, and drum contents and placement of non-visibly contaminated soils in a microbiological degradation basin. The overpacks were to be stored on-site in a drum storage building. This plan, prepared by Syntex and approved by EPA in February 1981, ensured worker health and safety and environmental protection through rigorously evaluated trench excavation, decontamination, and contingency plan procedures, as well as containment of wastes on-site in secured areas until a viable technology for ultimate treatment, destruction, or disposal emerged.

The decision to use the microbiological degradation basin technology at the Denney Farm site to detoxify soils contaminated with low levels of dioxin, among other contaminants, was based on laboratory studies and research conducted by Syntex Agribusiness, Inc. In part, Syntex based its rationale for using the technology on studies conducted by Dr. Fumio Matsumura, whose extensive studies on the natural and induced degradation of dioxin suggest that by controlling environmental conditions, dioxin-contaminated soils can be successfully detoxified (Bowers 1980).

In June 1984, EPA moved forward with a permit application to bring its mobile incineration unit on-site to be used in trial burn tests to determine its applicability for Denney Farm wastes. A permit was issued on October 19, 1984. Trial burning began sometime in January 1985. Although this technology had not been fully proven in in-field destruction of TCDD-contaminated wastes at this time, it was selected because it was considered the only viable alternative. This reasoning reflected the dilemma that EPA and Syntex were faced with in regard to the Denney Farm Site remediation. Quite simply, no proven technology for the destruction of TCDD in the conditions present at Denney Farm had emerged yet, nor were commercial firms or state regulatory agencies willing to accept this type of waste.

Extent of Response

The goal of EPA and Syntex in the Denney Farm cleanup was originally established in the consent decree: to remove and to permanently dispose of or destroy all hazardous wastes in or adjacent to the trench. This goal was further qualified to address "all hazardous wastes" as those wastes which posed an imminent and substantial threat to human health or to the environment based on the best scientific judgment available. No acceptable level of TCDD concentration in the trench or limits for TCDD levels in remnant soils were established. Therefore, meeting the goal set forth in the consent decree relied on scientists' evaluations as to what contaminant levels remaining at Denney Farm would not pose an imminent or substantial threat to human health or to the environment.

In April 1981, remedial action work began at Denney Farm. The trench was excavated, approximately 90 drums were recovered, and visibly contaminated soils were removed. Once this was complete, an additional 6-12 inches (15-30 cm) of soil were removed from the bottom and sides of the trench. The trench, when completly excavated, measured roughly 12 ft wide by 61 ft long and 5ft deep (4m x 19m x 2m). An estimated total of 140 yd^3 (117 m^3) of soil had been removed from the trench. A metal detector was then used to ensure that all of the drums had been removed from the trench. Backfilling of the trench was delayed until dioxin-contaminated soil samples, taken from the bottom and the sides of the trench, had been analyzed for dioxin. The samples were taken to ensure sufficient soil removal had occurred. Figure 5 shows the plan view and crosssectional view of the excavated trench wall and the bottom sampling scheme. Analyses of the samples revealed TCDD concentrations as high as 467 ppb (ug/kg) remaining in the bottom of the western end of the trench. Figure 6 shows the levels of TCDD found in samples taken at 6-inch (15-cm) intervals to a depth of 30 inches (76 cm) into the sidewalls and the bottom of the excavated trench. TCDD concentrations decreased dramatically with depth from the trench wall, yet 150 ppb (ug/kg) TCDD was found at a depth of 30 inches (76 cm) beneath the west end of the trench and 49.6 ppb (ug/kg) TCDD occurred at a depth of 30 inches (76 cm) into the trench's west end wall.

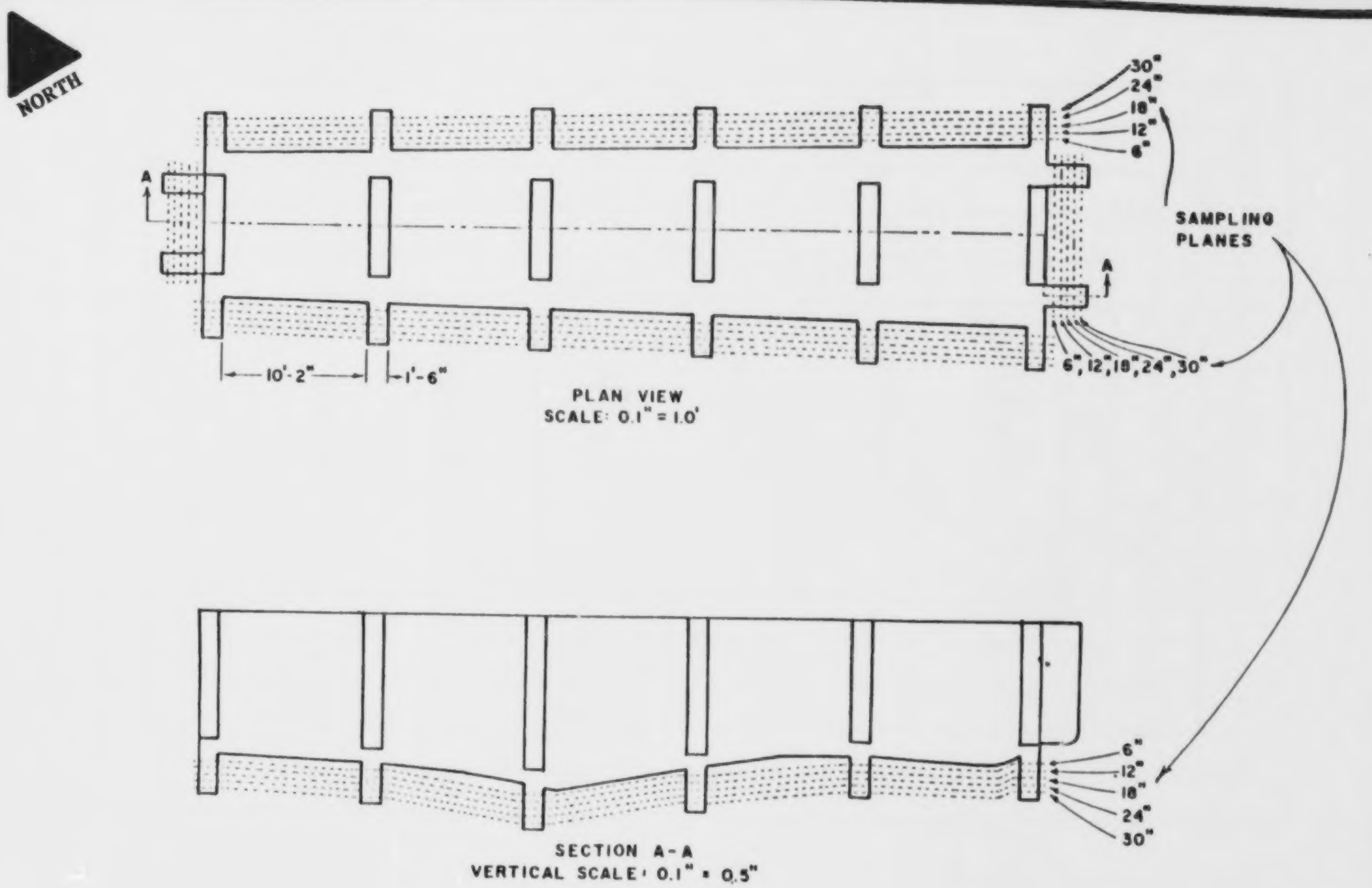
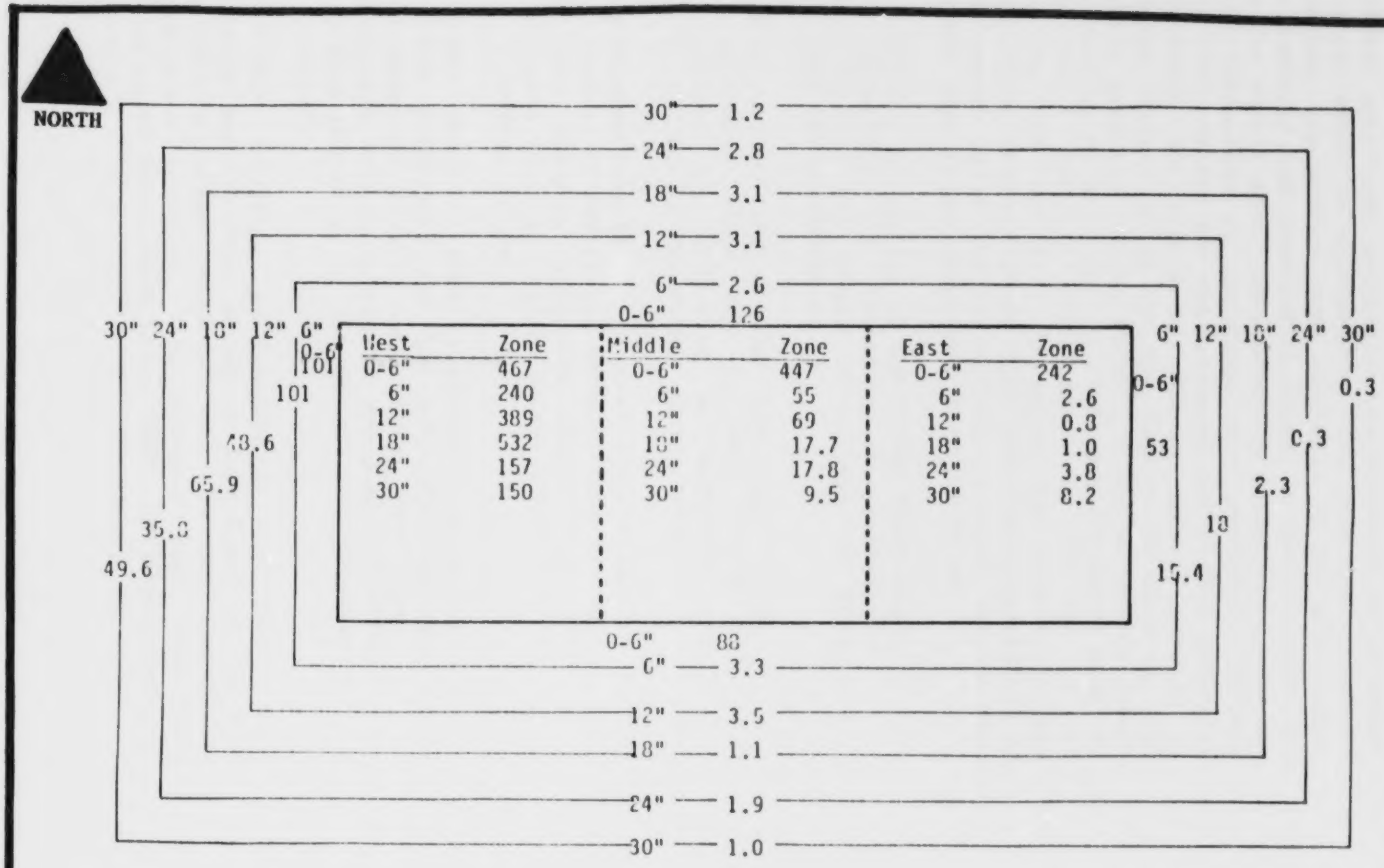


Figure 5. Trench Sides and Bottom Sampling Scheme Within the Excavated Disposal Trench at the Denney Farm Site

Source: US EPA 1981c



West	Zone	Middle	Zone	East	Zone
0-6"	467	0-6"	447	0-6"	242
6"	240	6"	55	6"	2.6
12"	389	12"	69	12"	0.3
18"	532	18"	17.7	18"	1.0
24"	157	24"	17.8	24"	3.8
30"	150	30"	9.5	30"	8.2

Figure 6. Schematic Diagram Showing Syntex TCDD Data in Parts Per Billion at Various Locations in the Denney Farm Trench

Source: US EPA 1981c

Several factors had to be considered to determine whether additional excavation was necessary or if trench closure would be appropriate. The principal factor to consider was whether TCDD remaining in the soils posed an imminent and substantial threat to human health and to the environment. To assess the threat posed, two on-site inspections of the trench were conducted. On July 24, 1981, Syntex and EPA personnel and an MDNR geologist inspected the trench to address various aspects of trench closure prior to the receipt of data on TCDD levels remaining in the trench. A second on-site trench inspection on September 24, 1981 was conducted with two additional geologic consultants, in addition to the persons who initially inspected the trench. This inspection occurred after TCDD levels were identified in the trench walls and the bottom. Several factors were agreed upon by the inspection team including:

- Further excavation of the trench floor might jeopardize the integrity of subsurface materials and result in releases of TCDD into the groundwater.

- Removal of all of the TCDD would be impractical since the procedure would be similar to "following an invisible ore vein," due to the nature of the subsoil.

- Reservations were expressed about selective removal of additional material from the west zone because effective backfilling and trench closure could be better achieved with a uniform bottom.

- The nature of TCDD to adhere to soils, its low solubility and low mobility, and the characteristically very dense, very impermeable soil would prevent any remaining TCDD from migrating if the trench were properly capped.

The consensus recommendation was that trench closure was the best action to take based on the best scientific judgment available that the remaining TCDD be considered immobile. In November 1981, the EPA's Chlorinated Dioxin Work Group (CDWG) and Dioxin Task

Force (DTF) agreed to Syntex's proposal to close the trench. An estimated 0.88 ounces (25 g) of TCDD remained bound in the trench, and the CDWG indicated that it did not consider the level or the amount of TCDD as necessarily acceptable in any other case, but approved trench closure based on the scientific judgments provided. The CDWG also indicated that it would take into account factors such as geology of the site and proximity to population centers in making decisions on a case-by-case basis for other TCDD contaminated sites. Trench closure, backfilling, and capping was completed on December 11, 1981.

All excavation, repacking of drums, and placement of non-visibly contaminated soils and decontamination waters in the microbiological degradation basin was conducted safely and efficiently. The contents of an estimated 90 waste drums were redrummed and the original drums overpacked and secured in the drum storage building. Approximately 3,765 cubic feet (107 m^3) of soil was removed from the trench and placed in a microbiological degradation basin. Composite sampling and analysis of soils taken on February 24, 1982 showed an average TCDD concentration of 630 ppb (ug/kg). Since EPA and Syntex did not believe that microbiological degradation represented an ultimate disposal or destruction measure, the soils and drummed wastes remaining at Denney Farm eventually had to be disposed of or destroyed. One option that was considered and has since been tested and proven to be successful was the use of EPA's mobile incineration unit at the Denney Farm site to destroy TCDD. However, it should be noted again that at the time incineration was proposed, no method, technology, or remedial action existed that has been proven acceptable in the destruction of TCDD in the numerous forms in which it is found at Denney Farm. By April 1985, the test burns on the Denney Farm wastes had been successfully completed using EPA's mobile incinerator. The test burn results are discussed further in the section entitled Performance Evaluation.

DESIGN AND EXECUTION OF SITE RESPONSE

The following section describes the remedial design, construction, and operations conducted at the Denney Farm site from April 1981 to June 1984. Figure 7 shows the access to the site, the fenced area, and the estimated trench configuration.

Remedial actions conducted at Denney Farm consisted of:

- Site preparation, support building construction, and temporary cap removal
- Excavation of waste materials
- Design and placement of non-visibly contaminated soils in two microbiological degradation basins (MDBs)
- On-site storage of drummed waste
- Trench backfilling and capping
- Plans for ultimate destruction/disposal of drummed wastes and contaminated soils.

The above remedial actions are discussed in the following sections.

Site Preparation

Before initiating cleanup operations, various support facilities had to be constructed and installed. These facilities included personnel and equipment decontamination areas, an operations trailer, an observation post, a drum storage building, and a trench protective structure. The personnel decontamination area consisted of a 5 by 10 feet (2 by 3 m) metal shed with two shower heads and a collection system for contaminated water. The equipment decontamination area was constructed with a 20 by 40 feet (6 by 12 m) sheet metal structure covering a concrete floor equipped with a sump collection system. Cleaning of equipment and waste material containers was to be accomplished with a portable high-pressure wash system. The operations trailer was constructed to provide a command post during trench excavation operations, as well as a rest area and an emergency shower for laborers. The temporary on-site drum storage area (TOSDSA) for the waste containers consisted of a steel-reinforced concrete basin 23 by 90 by 2 feet (7 by 27 by .6 m). Sheet metal walls and a roof totally enclosed the drum storage area. Two MDB's were constructed with dimensions of 23 by 90 by 4 feet (7 by 27 by 1 m). A three-sided cover constructed of sheet metal was placed over the MDB's, with one side left open

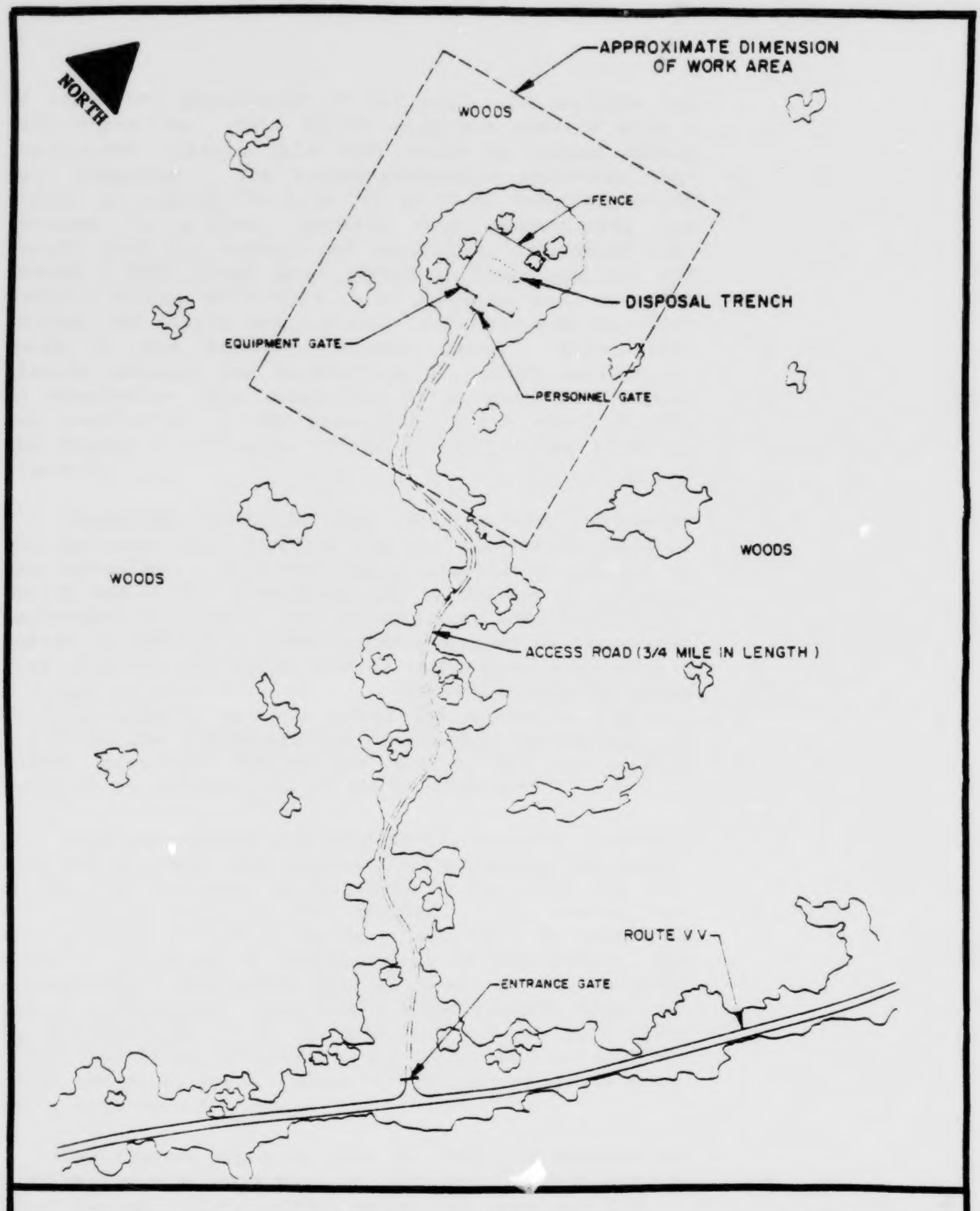


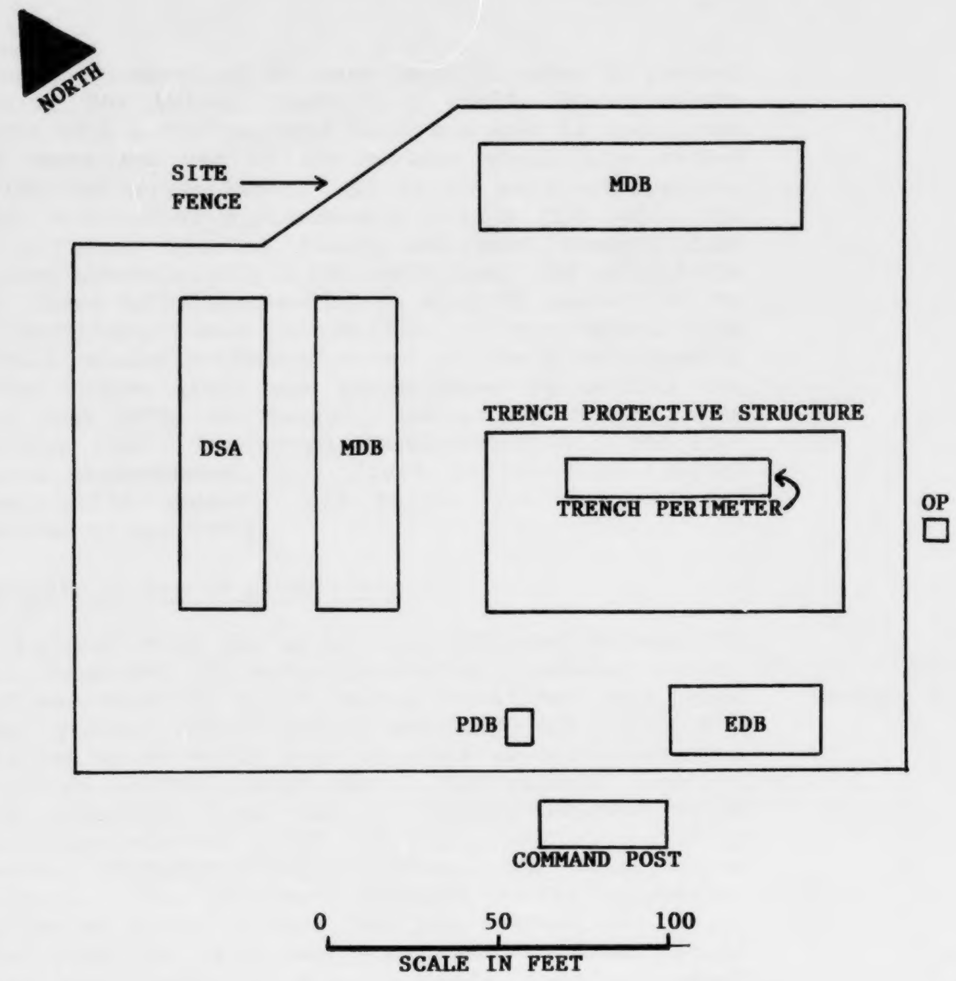
Figure 7. Access to the Site and General Layout of Fenced Compound Around Estimated Trench Boundary, Denney Farm, Missouri

Source: Syntex Agribusiness, Inc. 1980 to allow for emplacement of the soil. To minimize any dust migration, this fourth side was covered with a translucent plastic film that could be raised during soil placement. The trench-protective structure consisted of a 48 by 100 feet (15 by 30 m) temporary cover designed to prevent rainfall from encountering the trench once cap removal and excavation operations commenced. This cover also served to keep sunlight off workers during excavation. To minimize wind movement through the trench area, plastic film was used as sidewalls to the trench-protective cover. This clear plastic allowed for observation of trench activities. An observation post consisting of an elevated platform was constructed on the east side of the site, outside the fenced-in compound. These facilities are shown in Figure 8.

Concurrent with facility construction, personnel and equipment were prepared for the excavation phase of the operation. Personnel were intensively trained in health and safety procedures and in the use of personal protective equipment. All workers were additionally required to undergo a 7-day training course on first-aid, fire fighting and spill control techniques, including a thorough program orientation. The objectives of these training efforts were to reduce the amount of time required in the implementation of remedial operations, to ensure personnel health and safety, and to prevent releases of contaminants to the environment.

Upon the completion of support facility construction and personnel and equipment preparation, the impermeable cap, emplaced in July 1980 by EPA after the initial trench sampling, was removed. Cap removal was accomplished in such a way as to minimize the amount of material subjected to contamination in the trench. Approximately 4,000 cubic feet (113 m^3) of cap material had to be removed, including a basal plastic liner 40 by 100 feet (12 by 30 m), a 6-inch (15-cm) sand layer above that liner, a second equal dimension plastic liner above the sand, and 6 inches (15 cm) of pea gravel overlying this second liner.

Cap removal began on June 15, 1981. A backhoe was efficiently used to remove the pea gravel layer and the upper lining. Slow, careful operations were required



LEGEND

DSA - DRUM STORAGE AREA
EDB - EQUIPMENT DECONTAMINATION BUILDING
MDB - MICROBIOLOGICAL DEGRADATION BASINS
OP - OBSERVATION POST
PDB - PERSONNEL DECONTAMINATION BUILDING

Figure 8. Plan View of Denney Farm Site Showing Support Facilities

Source: Zirschky & Harris 1982

during the removal of the sand layer in order to prevent damaging the bottom liner. A small, 75-horsepower tractor with a rear-mounted blade was used to remove the sand where the use of the backhoe would have risked tearing the bottom liner. All of the sand was removed, except a layer of approximately 1 inch (2.5 cm). The gravel, upper plastic liner, and sand removed constituted approximately 3,800 cubic feet (106 m^3) of the cap. These materials, making up about 95 percent of the cap materials, were stockpiled as non-contaminated material on the northeast corner of the site. Removal of the bottom liner was accomplished by pulling the liner back with the backhoe and safely removing the remaining sand. The bottom plastic liner, which was considered contaminated, was placed in 55-gallon (208-1) drums. Cap removal took three days to complete, requiring 94 man-hours.

Excavation of Trench Materials

300.70(c)(2)(i)
excavation

Excavation of the trench was initiated on June 18, 1981. Personnel who worked inside the excavated trench, which was about 18 to 24 inches (46-61 cm) deep, wore rubber gloves, rubber boots, and acid suits with 3 m white cap hoods which were attached to air lines that ran to an external compressor. The various forms of waste materials found in the trench included solid wastes; contaminated soils; and liquid wastes, including solvents, flowable sludges, water, and other fluid materials. The procedure followed during excavation employed a vacuum system for the removal of liquid wastes from the drums and the trench. These liquid wastes were suctioned directly into stainless steel receiving tanks, which were in turn then drained into 55-gallon (208-1) drums. Drummed solid wastes were manually shovelled into new 55-gallon (208-1) drums. These methods allowed for the removal of as much of the drummed contents as possible without further spills or releases. The emptied drums were then lifted out of the trench and placed in 85-gallon (322-1) drum overpacks.

Soil was then excavated from the trench using a backhoe, as well as using some hand-shovelling. All of the soil excavated from the trench was considered contaminated. Visibly contaminated soil was placed in 55-gallon (208-1) drums. Non-visibly contaminated soil, having the same appearance as native soil, was excavated primarily by backhoe, and placed in the west MDB in bulk form. Liquids were placed in the east MDB, from which they evaporated.

Drummed solid waste and soils and the 85-gallon (322-l) drum overpacks were placed at the side of the trench on polypropylene pallets. A forklift was used to transport these pallets to the equipment decontamination area. Once the drums were in the decontamination building, a high-pressure wash was applied to remove any contaminated materials from their exterior. The drums were then taken to the TOSDSA facility for storage. The water used in the high-pressure wash of drums and equipment and in the personnel decontamination building was considered contaminated and pumped to the northern MDB. Throughout the operation, all hand tools and personal protective equipment that could be reused was decontaminated, with such items as leather work gloves disposed of in 55- gallon (208-l) drums. No major problems were encountered in the trench excavation operations, which required 20 project days to complete. An approximate total of 1,250 man-hours was needed to excavate the trench, with occasional interruptions for minor equipment malfunctions and worker breaks during high afternoon temperatures.

The marginal condition of drums removed - - many were crushed, in fragments, or corroded - - made the exact number of drums originally disposed of impossible to determine. However, approximately 90 drums were found and removed from the disposal trench. In addition to the removal of all of the drums and visibly contaminated soils, 6 to 12 inches (15 to 30 cm) of additional soil was removed from the sides and the bottom of the original trench and placed in the western MDB. In all, an estimated 140 cubic yards ($106m^3$) of soil was removed, with the final trench dimensions measuring roughly 12 by 61 by 5 feet (4 by 19 by 2 m). To determine if all of the drums had been removed, a metal detector was used. No additional drums or fragments were identified.

Analysis of one sample of liquid waste excavated at Denney Farm showed concentrations of TCDD as high as 2,000 ppm (mg/kg). Analyses of most of the other solid and liquid waste samples showed significantly lower TCDD concentrations, usually an order of magnitude lower or less. The waste recovered has been estimated to include approximately 300 gallons (1136 l) of still bottoms. A summary of the estimated volumes of TCDD, reported in July 1982, in various media from the trench and stored on-site include:

- Still bottoms - 25.7 ounces (730 g)
- Filter cake and/or visibly contaminated soil - 8.1 ounces (230 g)
- Other liquid-4.9 ounces (140 g)
- Soil in the western microbiological degradation basin - 4.9 ounces (140 g).

Sampling of the trench sides and the bottom was also conducted upon the completion of trench excavation. Originally, seven samples were composited from 88 sampling points. Analyses of these samples were performed to determine if sufficient soil had been removed. Initial analysis indicated additional sampling would be necessary. Sampling of the trench sides and the bottom was then conducted at 6-inch (15-cm) intervals to a depth of 30 inches (76 cm). The results of analyses of the samples, shown in Figure 6, reveal TCDD concentrations ranging from 0.3 to 467 ppb (ug/kg). Other conflicting reports indicate that concentrations as high as 532 ppb (ug/kg) remained in the soils on the western end of the trench. A July 1982 report estimated that approximately .88 ounces (25 g) of TCDD was actually left in place in the trench.

It should be noted that numerous qualified scientists were called upon to analyze the threat posed by the remaining TCDD in the trench sides and the bottom. As discussed in the Extent of Response section of this report, it was the consensus opinion that the TCDD remaining in place was immobile and that trench backfilling and capping, if done properly, would eliminate any threat to human health or to the environment.

Soil Placement in MDB

Preliminary research under sponsorship by Syntex indicated that TCDD levels might be reduced by microorganisms in the soil. The site plan proposed by Syntex and accepted by the EPA called for placement of non-

300.70(b)(2)(ii)
direct waste
treatment methods

visibly contaminated soils in a microbiological degradation basin (MDB). Figure 9 shows the construction plan used for both of the MDBs which were built prior to excavation. The interior dimensions of the MDBs were 23 by 90 by 4 feet (7 by 27 by 1 m), as built according to specifications. The soil volume excavated and placed originally in the western MDB was approximately 3,765 cubic feet (107 m^3). The basins as designed would have a capacity of 4,140 cubic feet (118 m^3) when filled to 3 feet (.9 m) of depth.

Several factors were incorporated into the MDB construction design to ensure leakfree operation. The vasins have 12- by 16-inch (30-by 40 cm) footings with 8-inch (20-cm_ thick floors and sidewalls. Floors and walls were reinforced with No. 6 reinforcing bars on 12inch (30-cm) centers. Walls have a 3-by 2-inch (7 by 5 cm) key into the floor with polyvinylchloride waterstop material at this joint and at any expansion joint to maintain the leakproof integrity of the basin. Twelveby 16-inch (30- by 40- cm) post foundations for the Microbiological Processing Buildings (or sheet metal cover structure) were integrally poured into the basin walls at 10-inch (25-cm) centers. Each post foundation had a 3- by .25 by 18 inch (7 by .6 by 45 cm) anchor strap and .5 by 2.75 inch (1 by 7 cm) anchor bolt set into the foundation.

The Microbiological Processing Buildings were designed to be installed on the top of the microbiological degradation basins, with dimensions of approximately 24 by 92 feet (7 by 28 m) by 10 to 12 feet (3 to 4 m) high. The joint where the concrete meets the sidewall was caulked with silicone caulking material. This caulked overlap was designed to eliminate the possibility of small animals or birds entering the Processing Buildings after the fourth side of the building was installed. During the excavation, the side facing the trench was left open to allow excavated soil to be placed in the western basin. Temporary reinforced plastic roll-up sidewalls were available to close off the open side when desired. The final wall of the structure was to be added upon completion of soil placement, with security-type locks used to prevent unauthorized entry.

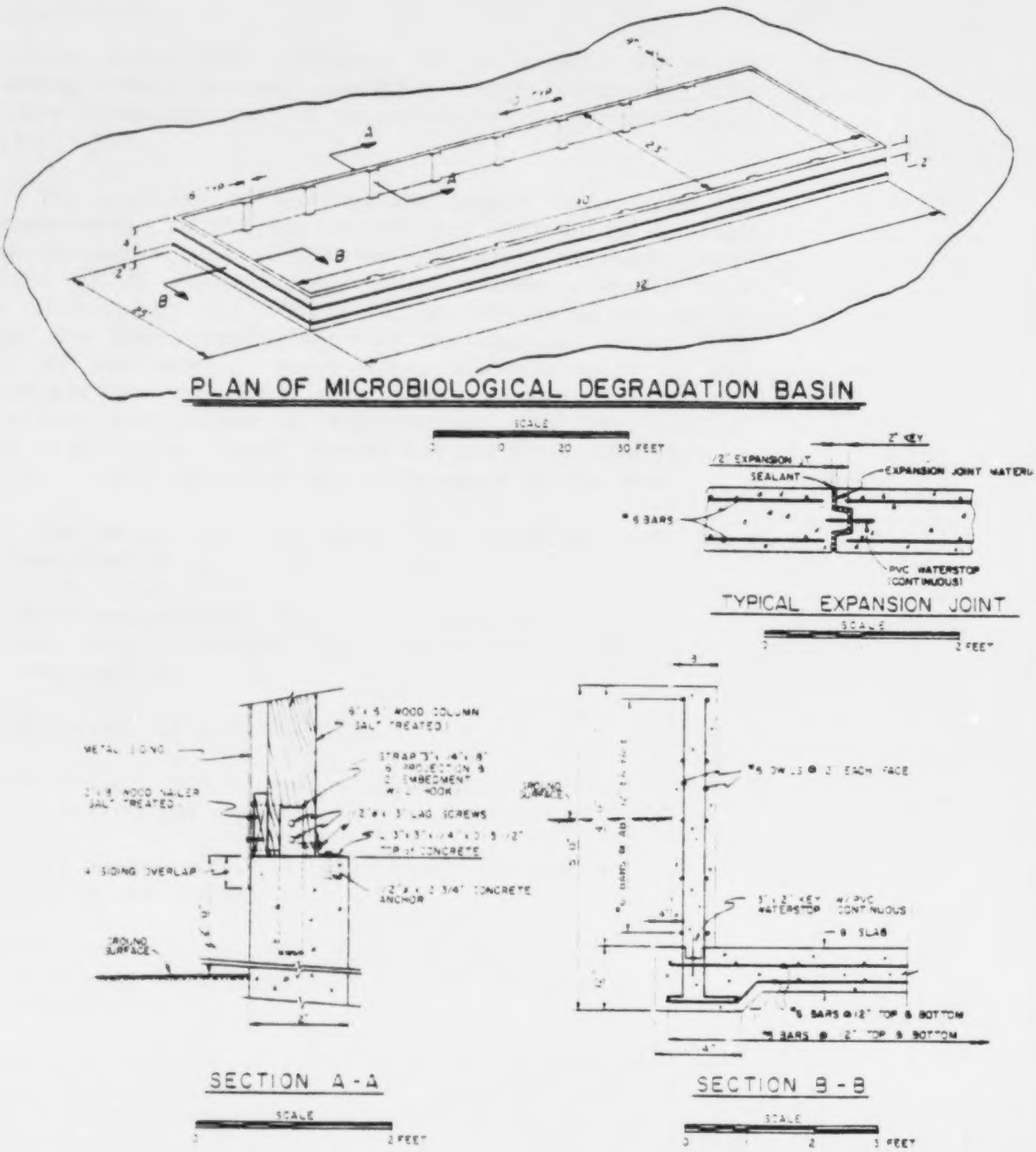

A
A
B
B
40
25
25
32
2
PLAN OF MICROBIOLOGICAL DEGRADATION BASIN
SCALE
0
10
20
30 FEET
2" KEY
1/2" EXPANSION JT.
SEALANT
EXPANSION JOINT MATERIAL
#5 BARS
PVC WATERSTOP (CONTINUOUS)
TYPICAL EXPANSION JOINT
SCALE
0
2 FEET
6" x 6" WOOD COLUMN (SALT TREATED)
METAL SIDING
STRAP 3" x 1/4" x 8" 6" PROJECTION & 2" EMBEDMENT WITH 2" HOOK
2" x 8" WOOD NAILER (SALT TREATED)
1/2" ø x 3" LAG SCREWS
L 3" x 3" x 1/4" x 0'-9 1/2"
TOP OF CONCRETE
4" SIDING OVERLAP
1/2" ø x 2 3/4" CONCRETE ANCHOR
GROUND SURFACE
2"
SECTION A-A
SCALE
0
2 FEET
8"
#5 DWLS @ 12" EACH FACE
GROUND SURFACE
#5 BARS @ 12" EACH FACE
3" x 2" KEY W/PVC WATERSTOP CONTINUOUS
8" SLAB
#5 BARS @ 12" TOP & BOTTOM
#5 BARS @ 12" TOP & BOTTOM
4'
SECTION B-B
SCALE
0
1
2
3 FEET

Figure 9. Engineering Plan of Microbiological Degradation Basin, Denney Farm Site, Missouri

Source: Syntex Agribusiness, Inc. 1980

The MDB's were designed to be capable of withstanding severe weather conditions. The estimated life of the structure is 50 years, with inspections made periodically.

The analysis of a composite sample taken from the western basin by the EPA in February 1982 showed average TCDD concentrations of 630 ppb (ug/kg). The sample consisted of 15 approximately equal volume aliquots from the surface to the bottom of the MDB. According to plan, the MDB's performance in the degradation of TCDD will be evaluated 5 years after the placement of all materials in the MDB, with TCDD assays performed to determine the extent of degradation. At the time of this writing, no formal report had yet been submitted to EPA by Syntex regarding the performance of the MDB.

The materials considered for blending with contaminated soils in the MDB included:

- Rich agricultural topsoil to promote microbiological growth and subsequent TCDD degradation

- Moisture, if needed

- Materials such as peat moss, muck soil, etc. to extend the depth of aerobic conditions

- Soil amendments, if additional sources of carbon are needed

- And possibly, an oil (e.g., soybean oil) or a solvent (e.g., ethylene glycol) to enhance degradation.

Plans were made to till the soil in the MDB once each during the spring and the fall, since microbial growth is best during those periods. Soil in the MDB was to be sampled and assayed annually to monitor the degradation process.

The implementation of the MDB was directed toward providing a treatment facility in the event microorganisms or a degradation technology could be developed during site remediation, and to test/research TCDD degradation further. Laboratory studies have not been promising and the MBDS are merely serving as storage facilities for the contaminated soil.

On-Site Drum Storage

The solid waste and visibly contaminated soils that were drummed in new 55-gallon (208-1) drums and the remaining buried drums and fragments that were placed in 85-gallon (322-1) drum overpacks constitute the materials stored in the TOSDSA. Prior to storage, each drum was sealed, its exterior was decontaminated, and it was labeled to meet Department of Transportation (DOT) and EPA requirements. These steps were taken not only to ensure temporary on-site drum storage security, but also to provide for drum transportation should off-site disposal be selected for ultimate fulfillment of the consent decree. A schematic view of the site for planned remedial efforts is shown in Figure 10. This figure does not include the second of two MDBs that was constructed, but does show the relative positioning of support buildings within the fenced area. Actual support facility locations onsite are shown in Figure 8.

Trench Backfilling and Capping

After trench excavation was completed in July 1981, analyses of trench side and bottom soil samples was required before backfilling and capping operations could proceed. A long turn-around time for low-level TCDD analysis and intensive on-site inspection of the trench to determine the potential for TCDD residue migration delayed the initiation of operations until November 24, 1981.

To allow for a better seal between the native soils and the backfill material, the trench sides were sloped. The trench was then backfilled with clay and compacted in 6-inch (15-cm) lifts. Trench backfilling required 9 days and an estimated total of 150 to 175 manhours. A cap consisting of four layers of material and spanning an area 35 by 100 feet (11 by 30 m) was then placed over the backfilled trench. The four layers in the cap consisted of (bottom to top):

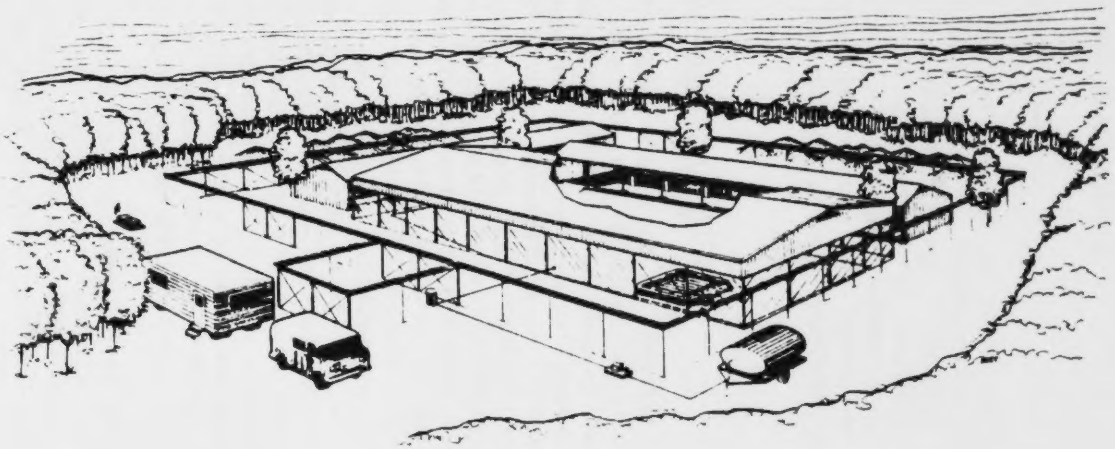


Figure 10. Schematic View of Denney Farm Site During Excavation Activities

Source: Syntex Agribusiness, Inc. 1980

- A 3-inch (8-cm) sand cushion
- A 35 by 10 foot (11 by 30 m) plastic liner
- A second 3-inch (8- cm) sand cushion
- And 6 inches (16 cm) of topsoil.

Sod was placed on top of the topsoil to stabilize the cap and to prevent erosion. The cap construction, requiring approximately 80 man-hours, was completed on December 11, 1981. Upon completion of excavation, storage, trench backfilling, and capping operations, an elaborate electronic security system was installed at the site, with site inspections being conducted on a weekly basis.

Plans for Ultimate Destruction/Disposal

The efforts of EPA and Syntex were to identify and to implement a technology for the destruction of the wastes and the contaminated materials at Denney Farm. The technology considered to have the greatest potential for the destruction of TCDD at Denney Farm is incineration. A permit application to use EPA's mobile incinerator to burn trichlorophenol still bottoms, solvents, activated carbon, drums, soil, and miscellaneous TCDD-contaminated trash at the site was submitted to the US EPA's Oil and Hazardous Materials Spill Branch (OHMSB) in June 1984. Prior to its approval in November 1984, the permit application underwent one major set of revisions and numerous information requests and submittal periods in response to comments from EPA Region VII and the Missouri Department of Natural Resources, regarding detailed procedures for ash handling, process wastewater handling, deliveries of wastes from off-site, and interim status permitting of storage facilities.

The incineration system that is being used is the EPA Office of Research and Development's mobile incinerator. The system's rated capacity is 4,000 pounds per hour (1.5×10^5 g/hr) of solid material and 800 pounds per hour (2.9×10^5 g/hr) for liquids. The solid, negligible, liquid waste heat content is 13,500 BTU/pound with an approximate firing rate of 48,000 pounds (1.8×10^7 g) of solids and 14,400 pounds of (5.4×10^6 g) liquid per day. The system is designed to test and to demonstrate the equipment and the technology at the Denney Farm site. Figure 11 shows the configuration of the mobile incinerator system at the Denney Farm site.

On October 19, 1984, EPA ORD's contractor for operating the mobile incinerator unit was issued a permit by EPA OHMSB for the operation of the incinerator at Denney Farm. The permit was effective on November 18, 1984. The trial burn began in late January 1985 and was completed in April 1985. During this time, five different mixtures (both liquid and solid) were incinerated. The first run involved a solid feedstock consisting of PCBs on montmorillonite mixed with hexachloroethane, and a liquid feedstock containing carbon tetrachloride and methanol. The second run of tests utilized a solid feed of dioxin-contaminated soils taken from the MBDs and a liquid dioxin feed mixed with methylene chloride and butanol. The third run utilized sludges from the lagoon impoundments located at the Syntex plant in Springfield, Missouri (US EPA 1985).

A principal objective of the trial burn, aside from the potential ultimate destruction of Denney Farm wastes, was to determine optimum feed rates for the destruction of TCDD-contaminated solids and liquids. The results of the trial burns are discussed in the Performance Evaluation section.

COST AND FUNDING

Source of Funding

All of the project costs for the remedial action were paid by Syntex Agribusiness, Inc. Prior to the remedial action, an immediate and temporary measure was taken by EPA with Clean Water Act Section 311 funding. Syntex later refunded $100,000 of the money spent for the immediate measure.

300.68(c)
responsible
party funding

Selection of Contractors

Ecology and Environment, Inc., of Arlington, Virginia produced the reports, "Technical Study and Remedial Action for Denney Farm Site 1, Aurora, Missouri" and "Work Plan and Site Safety Plan" for EPA

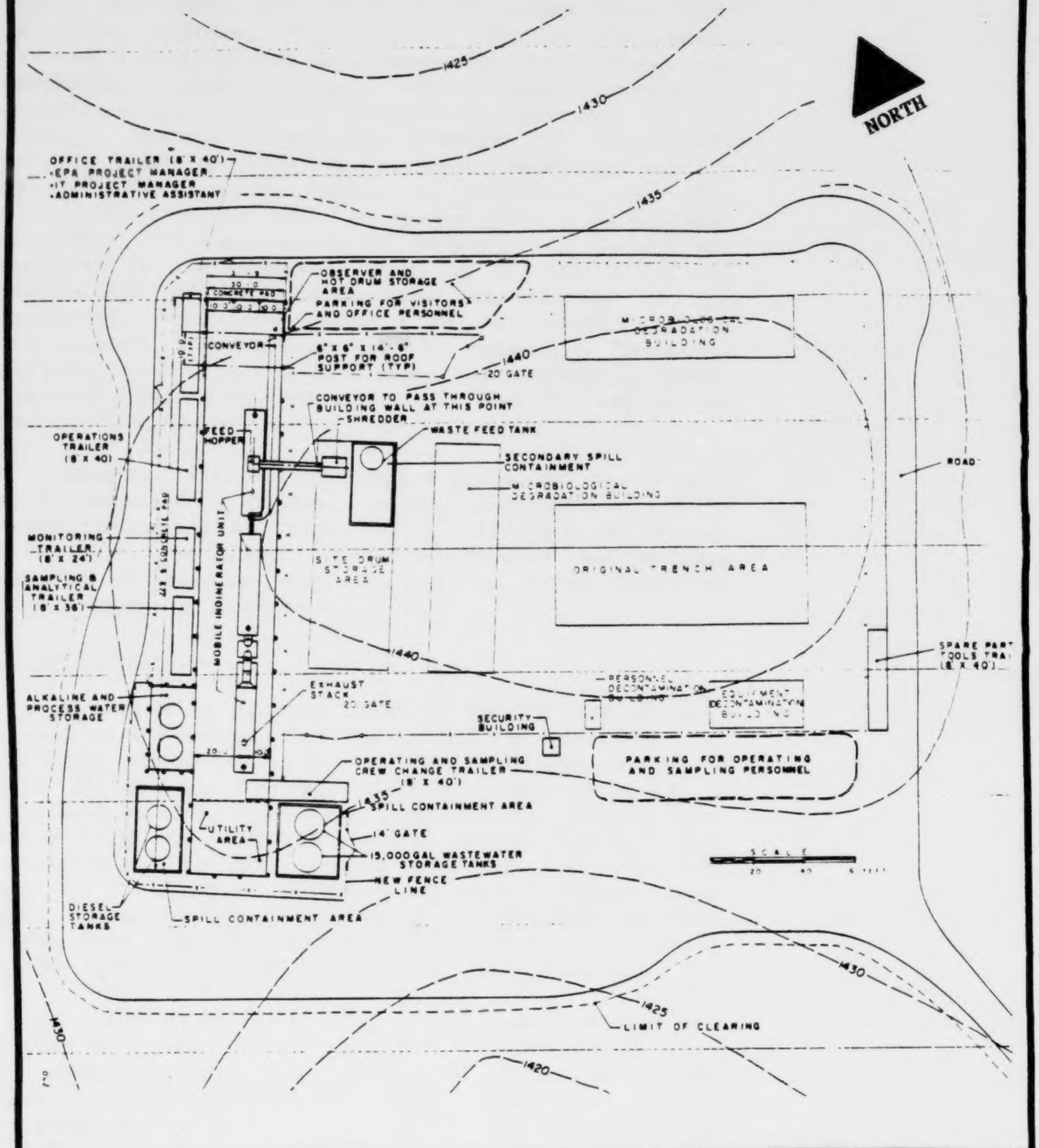

NORTH
1425
1430
1435
1440
1420
OFFICE TRAILER (8' X 40')
•EPA PROJECT MANAGER
•IT PROJECT MANAGER
•ADMINISTRATIVE ASSISTANT
OBSERVER AND HOT DRUM STORAGE AREA
PARKING FOR VISITORS AND OFFICE PERSONNEL
CONCRETE PAD
30'-0"
CONVEYOR
6" X 6" X 14'-6" POST FOR ROOF SUPPORT (TYP)
20' GATE
CONVEYOR TO PASS THROUGH BUILDING WALL AT THIS POINT
SHREDDER
WASTE FEED TANK
FEED HOPPER
SECONDARY SPILL CONTAINMENT
MICROBIOLOGICAL DEGRADATION BUILDING
OPERATIONS TRAILER (8' X 40)
MONITORING TRAILER (8' X 24')
SAMPLING & ANALYTICAL TRAILER (8' X 36')
MOBILE INCINERATOR UNIT
SITE DRUM STORAGE AREA
ORIGINAL TRENCH AREA
ROAD
SPARE PART TOOLS TRAI (8' X 40')
PERSONNEL DECONTAMINATION BUILDING
EQUIPMENT DECONTAMINATION BUILDING
SECURITY BUILDING
EXHAUST STACK
20' GATE
ALKALINE AND PROCESS WATER STORAGE
PARKING FOR OPERATING AND SAMPLING PERSONNEL
OPERATING AND SAMPLING CREW CHANGE TRAILER (8' X 40')
SPILL CONTAINMENT AREA
UTILITY AREA
14' GATE
15,000 GAL WASTEWATER STORAGE TANKS
NEW FENCE LINE
DIESEL STORAGE TANKS
SPILL CONTAINMENT AREA
SCALE
20
40
LIMIT OF CLEARING

Figure 11. Engineering Plan View of Proposed Incineration System Equipment Locations at the Denney Farm Site, Missouri

Source: IT Corporation 1984

Region VII under its Field Investigation Team (FIT) contract. Technos, Inc. of Miami, Florida was subcontracted to Ecology and Environment for the "Geologic and Geophysical Investigation", which used geophysical techniques to delineate subsurface conditions at the site. Canonie/D'Appolonia Company of Chesterton, Indiana later conducted a subsurface investigation for Syntex and assisted Syntex in developing the site plan. Drilling for soil borings was done by B. Williams Company. IT Corporation of Edison, New Jersey was involved in the research regarding detoxification and destruction of TCDD-contaminated wastes and is the permitted, contracted operator of the on-site mobile incinerator. IT Enviroscience of Knoxville, Tennessee assisted Syntex in the development of photolytic treatment of dioxin (an alternative examined for use at the Denney Farm site).

Chemical analyses of samples collected at the site were conducted by Syntex, by EPA laboratories, and by Brehm Laboratory of Wright State University in Dayton, Ohio (for the EPA). Site maintenance and various aspects of closeout were performed by Durbin Construction Company, a local firm.

Project Costs

At the time of this writing, the US EPA was preparing cost documentation for litigation involving cost recovery procedures. Due to the sensitive nature of this litigation, EPA-incurred costs were regarded as confidential and, therefore, unavailable. Syntex cost information regarding the remedial action plan were also unavailable. To date, Syntex costs are still unknown, even to the US EPA. A number of cost estimates, however, were developed, including various options that might have been used. Estimate information pertaining to the option selected is presented in this section.

It should be noted that the information that was available in the form of estimates did not always cover the same components that Syntex used in the implementation of the Denney Farm Site Plan. For example, the FIT estimate did not include the construction or utilization of microbiological degradation basins, which were actually used, and off-site temporary storage was included in these estimates, although on-site storage was actually used. Furthermore, certain assumptions were made in the estimates which later were shown to be inaccurate. These included the amount of soil excavated (estimated at 1,200 cubic yards (917 m^3) actual 140 cubic yards; 107 m^3), the number of manhours required (estimated at 1490, 1250 actually used), the number of drums used, and other items.

However, because the estimates from the FIT do reflect, in part, the work that occurred at the site, they are included in Table 3. An item-by-item description of elements of Table 3 is given later in this section.

Estimates on the cost of the immediate and the temporary response implemented by EPA and other activities undertaken before the remedial action were available. Cost information covering the excavation of 13 drums, the sampling and analysis of eight drums, site clearing, 460 feet (140 m) of 9-foot (2.7-m) high fencing, two 4,000-square foot (371-m^2) layers of 20-mil (0.5-mm) plastic, sand, and gravel covering the trench, and related construction activities, is detailed in Table 4.

The only other indication of actual costs were those given in a firm, fixed - price bid estimate submitted by the remote sensing survey contractor. The components of this price bid estimate are shown below in Tabie 5. The remote sensing survey consisted of mobilization and review of available data, two days of conductivity testing, one day using seismic and magnetic detection devices, one day using ground penetrating radar, and ten days of analysis and reporting.

The FIT estimate, as summarized in Table 3, is given in the final report of the "Technical Study and Remedial Action for Denny Farm Site 1, Aurora, Missouri," submitted September 15, 1980. The estimate was prepared with a partial knowledge of the remedial actions that were to be implemented later. Fixed costs on this estimate totalled $1,219,000. With 70 percent overhead and profit added on, plus a 20 percent contingency fee calculated for the sum, total estimated costs came to $2,486,000. Items that deviate from what was actually used are listed in the following discussion.

TABLE 3. SUMMARY OF ESTIMATED PROJECT COSTS DENNEY FARM SITE

Task	Estimated Expenditure	Unit Cost	Period of Performance (actual)
Site Set-up and Mobilization	$ 367,000	- -	April 1981-June 1981
Temporary Storage Facility for 5,000 drums	$ 360,000	$72/drum	April 1981
Excavation	$ 467,930	$1,080/cu yd	June 1981-July 1981
Site Closure	$ 23,810	- -	December 1981
Overhead and Profit (70%)	$ 853,000	- -	- -
Contingency (20%)	$ 414,000	- -	- -
Total Project Estimate	$2,486,000	- -	- -

Source: E&E 1980

TABLE 4. ACTUAL COSTS OF VARIOUS PRE-CLEANUP ACTIVITIES

ITEM	Cost	Unit Cost
Physical Examinations	$ 665	N/A
SCBA	$ 5,676	$ 500
SCBA Cylinders	$ 1,470	$ 147
SCBA Parts	$ 2,356	N/A
Compressor with CO Monitor	$ 2,340	$2,340
Backhoe Rental	$ 500	$ 25/hr
Security Fence with Barbed Wire	$ 7,000	N/A
Cleaning Site and Road	$ 490	N/A
Total Cost	$20,497	

Note: This summary does not include direct labor, overhead, or fees.

Source: USEPA 1980b.

TABLE 5. COSTS OF GEOPHYSICAL SURVEY

Direct Labor	$16,200
Equipment Charge	6,500
Mobilization Costs	4,000
Per Diem	1,300
Report	3,000
Management and Fee	5,000
Total Cost	$36,000

Source: Technos, Inc. 1980

Estimated costs of site set-up and mobilization are given in Table 3. Items used in the implemented design, but not included in the original estimate, include: a radio antenna, a gasoline storage cabinet, a fuel oil tank, an equipment decontamination area, firefighting water supply tanks and pumps, vacuum suction system, weather instruments, CB radios, laboratory equipment, spark-proof tools, two microbiological degradation buildings, two vans, camera equipment, an air compressor for SCBA, a guardhouse, a trench-protective structure and ventilation system, and a pressure washer. Items that were changed somewhat, but included in both the estimate and the implemented design, include: cleaning and grading of site, personnel decontamination structure, temporary drum storage area, operations trailer, portable water supply tank, and personnel training.

Items that were included in the estimate, but not used in the remedial action, include: the purchase of one acre of land, a crew trailer, a canvas trench cover, conveyors, metal grate walkways, a crane, a flatbed truck, and a water truck. Also, estimates of labor, water usage, drums needed, and soil excavated all varied from the amounts needed at the site.

PERFORMANCE EVALUATION

The objective of the remedial action at the Denney Farm site, as stated in the consent decree, is the "implementation and monitoring of the results thereof, of the best practicable plan for removal and permanent disposal by containment, destruction, or other means (disposal) of all hazardous wastes located in and immediately adjacent to the Disposal Trench which ... pose an imminent and substantial endangerment to human health or to the environment." It should be noted that the formulation of the Denney Farm Site Plan occurred before CERCLA was enacted and before the National Contingency Plan (which provides a protocol for site planning) was available.

Three days after the initial telephone conversation of EPA Region VII personnel with the confidential informant, a reconnaisance team went to the site to investigate the situation. Their extensive investigation, consisting of interviews, a preliminary site survey, and a review of available files, led to the submission of a draft study plan 14 weeks later. Implementation of the study plan began 3 months after it was submitted, and only 6 months after initial notification of the problem was received. These efforts demonstrate an extremely rapid, and yet carefully planned approach to characterizing the Denney Farm site.

After the trench was initially sampled, it was secured by backfilling it with materials that had been previously excavated. Other measures taken to mitigate the flow of contaminants from the trench and to segregate the site from humans or animals included the construction of a temporary cap over the trench and the emplacement of a fence around the site. All activities were conducted without incident of risk to the environment or exposure to the workers, and they effectively reduced the potential for further such risks.

The Denney Farm Site Plan, in accordance with the goals stated in the consent decree, called for excavation of the trench, on-site storage of visibly contaminated wastes and soils, and treatment of non-visibly contaminated soils in a microbiological degradation basin. Numerous alternatives were considered in an attempt to identify a remedial action or technology for the ultimate destruction or disposal of the contaminated materials. However, Syntex and EPA officials decided that excavation and containment of wastes was imperative. Since the containment, they made a continuing effort to identify a means for the destruction or the disposal of the wastes. The dilemma that faced EPA and Syntex, at the time of this writing, was the lack of a demonstrated and proven technology to destroy or to dispose of TCDD- contaminated materials. Facts of the Denney Farm site cleanup show that, even with thorough planning and effective implementation of a temporary remedial response at the time, the ultimate destruction or disposal of dioxin-contaminated wastes was a goal that was beyond the demonstrated and proven technology.

Construction of support buildings onsite, personnel training, and equipment preparation proceeded on schedule with trench excavation beginning in June 1981. Because of the exceptional cooperation between EPA and Syntex and the adherence to a well-devised plan, excavation of the trench was performed without any known release of wastes to the environment or worker exposure.

The materials removed from the drums and the visibly contaminated soils were placed in new 55-gallon (208-l) drums and stored on-site. Non-visibly contaminated soils were placed within the western MDB, liquids were placed in the eastern MDB, and the drums themselves were placed in 85-gallon (322-l) drum over-packs and also stored on-site. The efficiency of excavation activities is commendable, particularly in the face of the dangers posed by the operation.

There is presently no indication of off-site migration of contaminants. Soil sampling was conducted from the trench sides and bottom after excavation was complete. Analyses of the samples showed that TCDD remained in the soils, indicating that prior to excavation, contaminant migration had begun and was a real threat to groundwater beneath the site. This fact was cause for concern and required a thorough evaluation regarding the appropriateness of trench closure. In accordance with conditions of the consent decree, the best scientific judgment available concluded that the TCDD remaining in the trench could be considered to pose no imminent or substantial threat. This judgment was based on the highly impermeable nature of the soils, the low mobility of the dioxin, and the remoteness of the site. Consequently, trench backfilling and capping activities were conducted. A multilayered impermeable cap placed over the backfilled trench combined with the method of backfilling used should ensure the future containment of contaminants at the site.

The fate of the drummed wastes and the containers stored on-site and the contaminated soils located in the MDB was uncertain at the time they were placed in storage. Since this time, a permit to use EPA's mobile incineratior at Denney Farm was issued and the trial burns were completed. The testing was conducted under the strict surveillance of local, state and federal authorities to ensure the system was operated safely and in accordance with trial burn permits.

The USEPA's review of the Denney Farm trial burn results indicates that the performance goals for stack emissions, clean ash, and clean cooling water have been achieved. There has been no 2,3,7,8-TCDD detected in the stack, ash or cooling water. In addition, the incinerator system easily meets the federally required 99.9999 percent destruction and removal efficiency criterion for the destruction of dioxin. Table 6 summarizes the results of the burns conducted during the period from February 26, 1985 to April 9, 1985. Specifically, the incinerator destroyed 3.84 pounds of 2,3,7,8-TCDD in the 1,750 gallons of liquids and over 40 tons of soil. The system met particulate emission permit limitations in three of the four test runs. The fourth run exceeded the prescribed limit only slightly because submicron-sized particles accumulated in the air pollution control system. The observed carbon monixde (CO) emission values (1.3 to 7.7 parts per million) are equivalent to those from the best incineration technologies available today. Following the analysis of the treated soil (ash) and process wastewater for a series of likely contaminants as established by the Office of Soil Waste under the Resource Conservation and Recovery Act, EPA has proposed that the residues from future dioxin burns be delisted (designated as not hazardous). The success of the trial burns in complying with regulations for destruction efficiency determined how the wastes and contaminated soils at Denney Farm would be ultimately handled. Actual burning of Denney Farm wastes is tentatively scheduled for late Summer of 1985.

TABLE 6. RESULTS OF DIOXIN TRIAL BURNS (2/26/85 - 4/9/85)

Parameter	Permit Limit	Test Number 2-2**	2-3	2-4	2-5
Rotary Kiln (Primary burner)					
Temperature (degrees celsius)	760-1040	845	826	902	918
Secondary burner					
Temperature (degrees celsius)	1120-1315	1153	1199	1194	1199
Retention time (seconds)		2.5	3.2	2.5	2.6
Oxygen (O2) (percent by volume)	4	7.96	6.61	6.44	6.42
Carbon monixide (CO) (ppmv)	100(6 min.)	7.7	1.3	2.3	2.5
Carbon dioxide (CO2) (vol. %)		10.9	11.3	11.4	11.1
Combustion efficiency (C.E.)(%)		99.993	99.999	99.998	99.998
Liquid waste feed					
Total flow (pounds per hour)		233	236	234	247
2,3,7,8-TCDD (grams per hour)	27.2	26.3	38.3	28.0	25.2
Solids feed					
Total flow (pounds per hour)	2000	1158	1163	2068	1322
2,3,7,8-TCDD (grams per hour)		0.05	0.24	0.95	0.46
Stack					
Emission rate: 2,3,7,8-TCDD (milligrams per day)		ND(0.169)	ND(0.127)	ND(0.031)	ND(0.064)
Particulates (miligrams/standard cubic meter, corrected to 7 prcent oxygen)	180	134.3	147.3	145.6	201.5
Destruction and removal efficiency (DRE) (%)	99.9999	99.99997	99.99998	99.99999	99.99998

ND = not detected (detection limits inside parantheses);

** Test 2 liquid feed: dioxin-contaminated TCP still bottoms
soil feed: TCP still bottoms + contaminated soil

Source: USEPA 1985c

Conditions of the consent decree not only required ultimate destruction or disposal, but also restricted temporary on-site storage to a period of 5 years from the final approval of the remedial response plan. Since the plan was accepted in February 1981, this deadline required that an alternative be developed by February 1986, if incineration had not proven successful. In addition, materials that were placed in the MDB had to be dealt with because, from the information available, the degradation process could not be considered ultimate destruction or disposal.

In summary, remedial response efforts at the Denney Farm site with respect to site characterization, trench excavation, on-site storage, backfilling, and capping activities were conducted in an efficient and a safe manner. The direction of technical efforts to implement these responses was timely and showed excellent cooperation between Syntex and EPA. No evaluation regarding the cost-efficiency of these efforts can be made, since EPA cost information was restricted due to ongoing litigation involving this site, and Syntex costs were unavailable. At the time of this writing, the mobile incinerator trial burns were complete and the results indicated that incineration was applicable for the Denney Farm wastes. The actual burning of the wastes, however, had not yet commenced. Therefore, an evaluation of the final response action could not be made at this time.

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GULF COAST LEAD
TAMPA, FLORIDA

INTRODUCTION

Gulf Coast Lead (GCL) is a small, secondary lead smelting facility in Tampa, Florida, incorporated in 1958, which recovers lead from discharged lead acid batteries and lead groupings from other battery breakers. Until 1979, contaminated rinsewater and battery casings from plant operations were dumped into an unlined surface depression near the center of company property. This action caused the soil and the shallow groundwater to become heavily contaminated with sulfuric acid and heavy metals, thus presenting a threat to the underlying Floridan Aquifer, one of Tampa's drinking water sources. Surface runoff from the battery casing area also threatened to enhance the spread of contaminants to off-site areas. A Federal suit filed in October 1980 under RCRA Section 7003 resulted in a consent decree, which was signed later that month. Under this consent decree, the contaminated rinsewater discharge was eliminated, the site was capped, a groundwater recovery and treatment system was installed, and a program for surface water retention and monitoring was started.

NCP Reference

300.65(a)(2)
drinking water
threat

Background

The Gulf Coast Lead Company obtained their present 9.91-acre (4-ha) site in 1964 from the Quaker Oats Company. The site is located in an industrial/residential area near the intersection of 66th Street and 10th Avenue in Southeast Tampa. The closest public drinking water well is approximately 1,000 feet (305 m) southwest of GCL property, and five private wells are within a 1/4-mile (0.4-km) vicinity.

300.68(3)(2)(i)(A)
population at risk

Plant operations at GCL begin with the purchase of old batteries and lead groupings from various suppliers who haul the material directly on-site to the smelting facility. The lead groupings are fed directly into the smelter, but the lead in the batteries must be removed prior to smelting. The battery recovery process consists of sawing off the battery top and then removing the lead plates or groups from the rubber or plastic cases by a slow-speed tumbler. A counter-current wash separates the plastic from the rubber and residual grid metal. The lead plates are fed to the smelter and, currently, the casings are crushed, chipped, and sold to plastic and rubber recyclers. Wash water from the counter-current separator is treated with caustic soda and lime and discharged to the city sewer.

Prior to 1979, contaminated rinsewater from the battery reclaiming operation, estimated at 1,200-1,800 gallons per day (gpd) (4,540-6,810 l/day), was poured onto the ground and the empty battery casings were piled in this same area. This practice allowed wastes to percolate through the soil and into the shallow groundwater below. Additionally, spent casings were left uncovered and came into contact with rainwater, creating an acidic surface runoff.

300.64(a)(2)
identification of source and nature of release

The problem was discovered in December 1978 by the Hillsborough County Environmental Protection Commission (HC EPC) during an effort to bring all secondary lead smelting and battery recycling operations in the country into compliance with State and local regulations. The HC EPC required that GCL begin monitoring the groundwater on site. Later, in June 1979, the Florida Department of Environmental Regulation (DER) became involved when it issued a compliance schedule and a 2-year temporary operating permit for a wastewater treatment system to reduce the levels of contaminants found in the GCL rinsewater. At the same time, citizen complaints prompted a Federal investigation of the GCL site by the U.S. EPA Region IV office. This investigation led to the lodging of a consent agreement that resulted in the implementation of a remedial plan addressing contamination at the site.

300.63(a)(4)
discovery of release

300.68
initial remedial measures

300.68(c)
administrative process

The consent decree, lodged on October 30, 1980, reinforced the provisions of the earlier State-issued compliance order requiring connection of GCL's wastewater discharge to the city sewer system. However, the consent decree went further by requiring: (1) a detailed assessment of groundwater, soil, and surface water contamination found on-site and off-site; (2) the development and implementation of a remedial plan to address on-site contamination identified during the detailed assessment; and (3) the development and implementation of a contingency remedial plan to address any off-site contamination later found to be attributable to the GCL operations. The consent decree stated that the EPA and GCL did not agree on whether GCL caused any off-site contamination.

In accordance with the provisions of the consent decree in 1981, GCL submitted a plan of study, a report on contamination, a remedial plan, and a contingency remedial plan. In addition, GCL hooked their wastewater treatment system to the City of Tampa's sewer system in June 1981. The remedial plan and the contingency remedial plan were not immediately accepted by the U.S. EPA. This prompted several draft stipulations to the consent decree in the fall of 1981 to address differences between GCL and EPA concerning the extent and the nature of the proposed site response. After these failed, GCL's and EPA's contractors conducted separate aquifer tests to predict the outcome of the proposed site response. These tests were conducted in the winter of 1981 and the summer of 1982 and resulted in EPA's acceptance of revised remedial and contingency remedial plans in late 1982. Most of the construction work for the remedial plans was finished in 1983 and the withdrawal and treatment of contaminated groundwater began in March 1984.

Synopsis of Site Response

After the consent decree was filed and before an agreement was reached on the remedial and contingency remedial plans, GCL implemented the following actions:

- Expanded the groundwater monitoring system

300.68(f) survey and monitoring

- Removed the remaining exposed battery casings
- Connected the battery wash water discharge to a new on-site treatment system which, in turn, discharges to the City of Tampa sewer system.

300.65(b)(4) controlling source of release

After an agreement was reached on the remedial plans, GCL implemented the following actions:

- Expanded the groundwater monitoring program further
- Installed a clay cap on and sodded part of the site, and installed an asphalt cap over another part of the site

300.70(b)(1)(iii)(A) impermeable barriers

- Installed a retention basin to collect and recycle contaminated surface run-off from the site

300.70(b) surface water controls

- Installed an underdrain system to collect rainwater runoff from uncontaminated areas for discharge to the City of Tampa storm drains

  300.70(b)(1)iii)
  (d)(1)
  subsurface drain

- Installed a groundwater withdrawal and treatment system consisting of 7 withdrawal wells over the most contaminated area and 20 additional well points along the southwestern boundary of the site. Pumpage from this recovery system is treated prior to being discharged to the city sewer system.

  300.70(b)(2)(ii)
  (A)(3)
  groundwater
  pumping

SITE DESCRIPTION

The Gulf Coast Lead Company occupies 9.91 acres (4 ha) in a mixed residential and industrial area about 7 miles (11 km) southwest of downtown Tampa (Figure 1). The surface characteristics and hydrogeology of the GCL site are discussed below.

Surface Characteristics

The GCL site is fully enclosed by a 6-foot (1.8-m) chainlink fence, which has one north-facing gate at the end of 66th Street. Immediately south of the site is a large railroad switching yard owned by the Seaboard Coast Line Company (Figure 2). Private residences lie beyond the northern boundary of GCL, and a large concrete products company is beyond the western fence line. A city-owned drainage ditch, about 20 feet (6.1 m) wide and 8 feet (2.4 m) deep, flows due south toward the northwest corner of the GCL site, where it turns due west. A tributary of this ditch flows due north, parallel to and about 300 feet (91 m) west of the western boundary of the GCL site.

300.68(e)(2)(i)(A)
population at risk

The terrain at the site slopes gently to the southwest at less than 10 feet (3 m) per mile. Annual rainfall in the vicinity averages 50 inches (127 cm), with an annual evapotranspiration rate of about 40 inches (102 cm).

Hydrogeology

The first 10 to 15 feet (3 to 4.5 m) beneath the GCL site is composed of a silty sand layer that slopes gently southwest (Figure 3). This silty sand layer exhibits permeabilities between 3.3×10^{-5} and 4.9×10^{-4} ft/sec (1×10^{-3} and 1.5×10^{-2} cm/sec), and comprises the uppermost aquifer in the area. The groundwater in this aquifer is between 2 to 3 feet (0.6 to 0.9 m) beneath the ground

300.68(e)(2)(i)(D)
hydrogeologic
factors

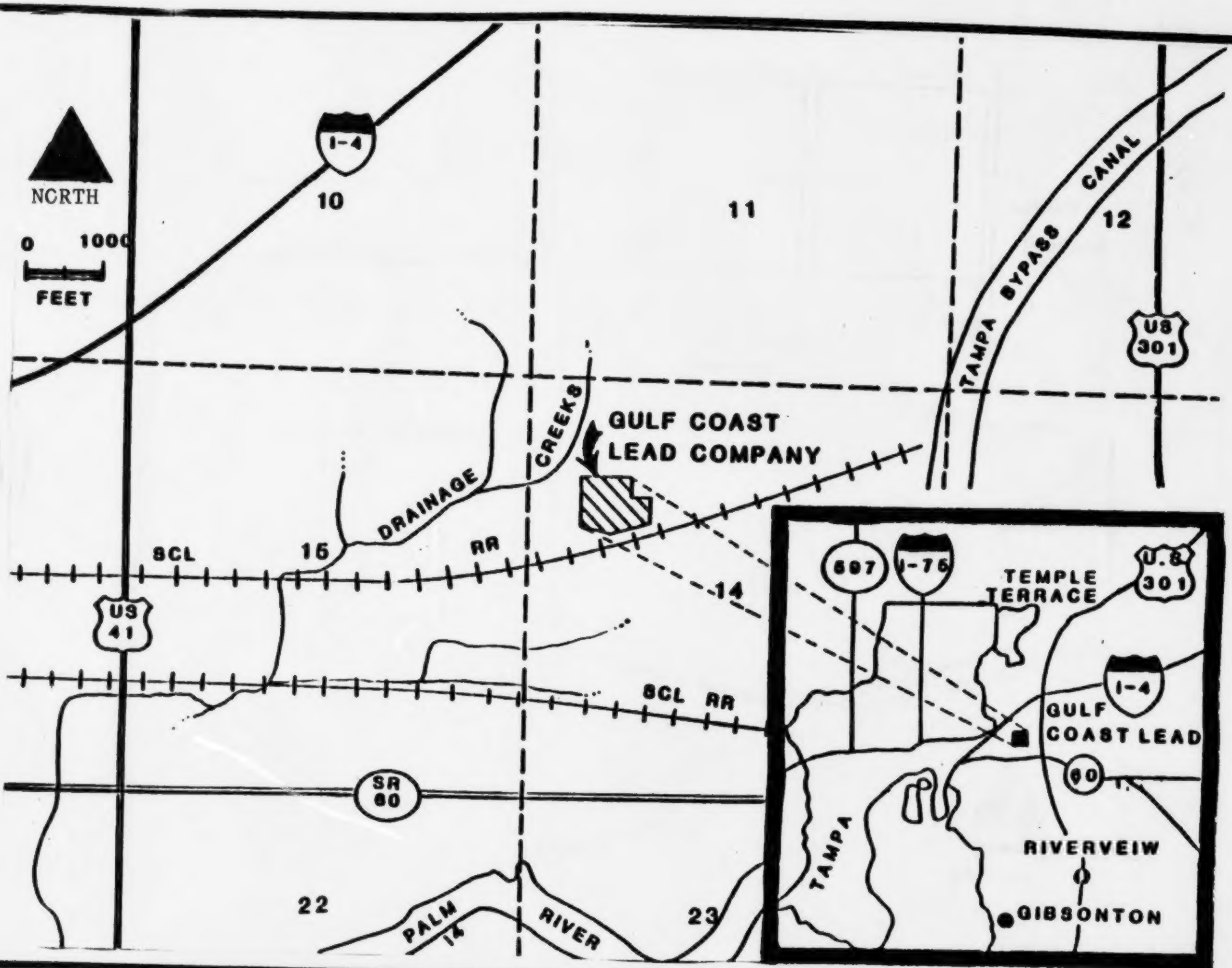

Figure 1. Location of the Gulf Coast Lead Company

Source: Environmental Engineering Consultants 1981

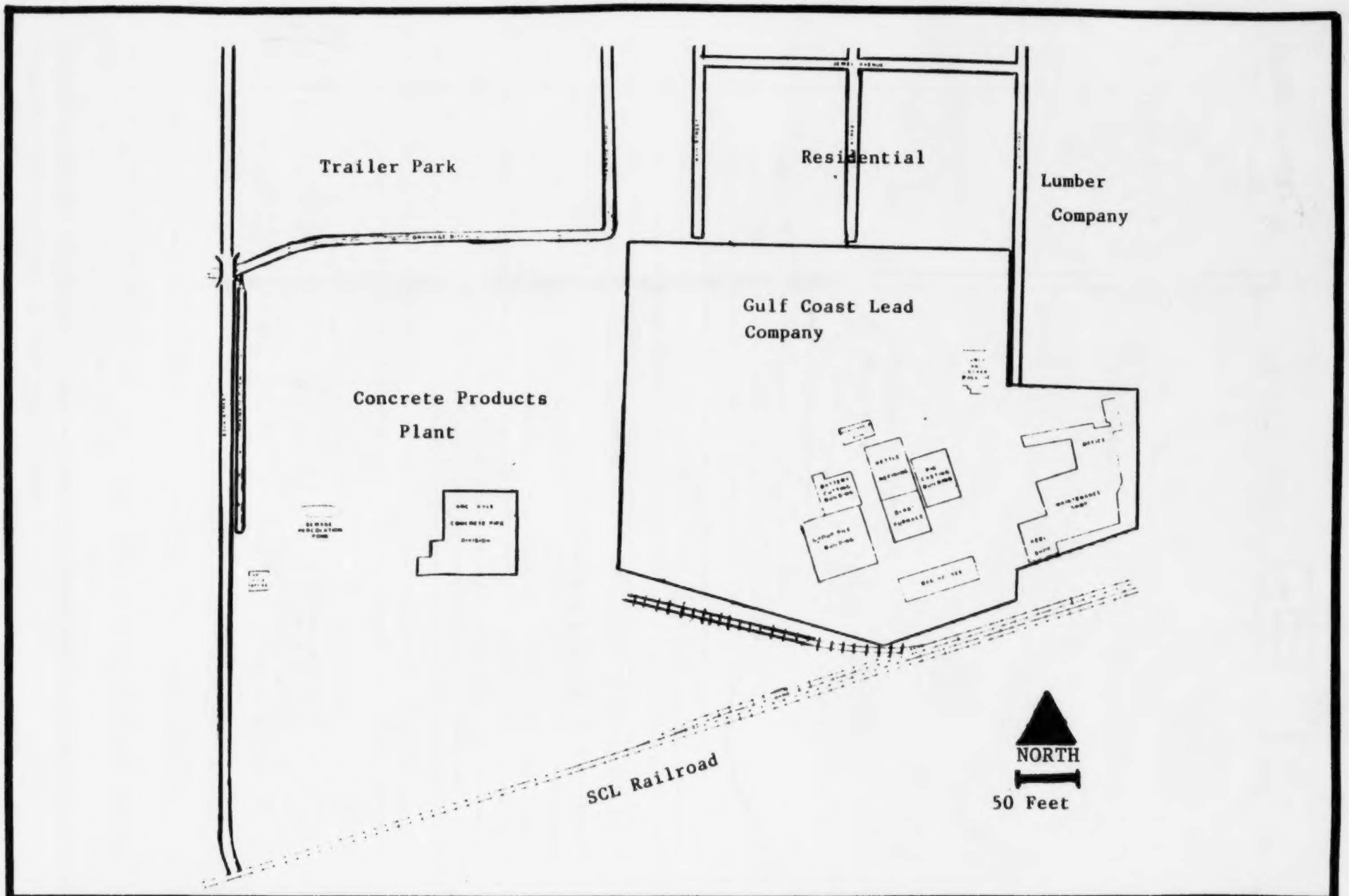

Figure 2. The Gulf Coast Lead Company and Surroundings

Source: Modified from Seaburn and Robertson, Inc. 1981

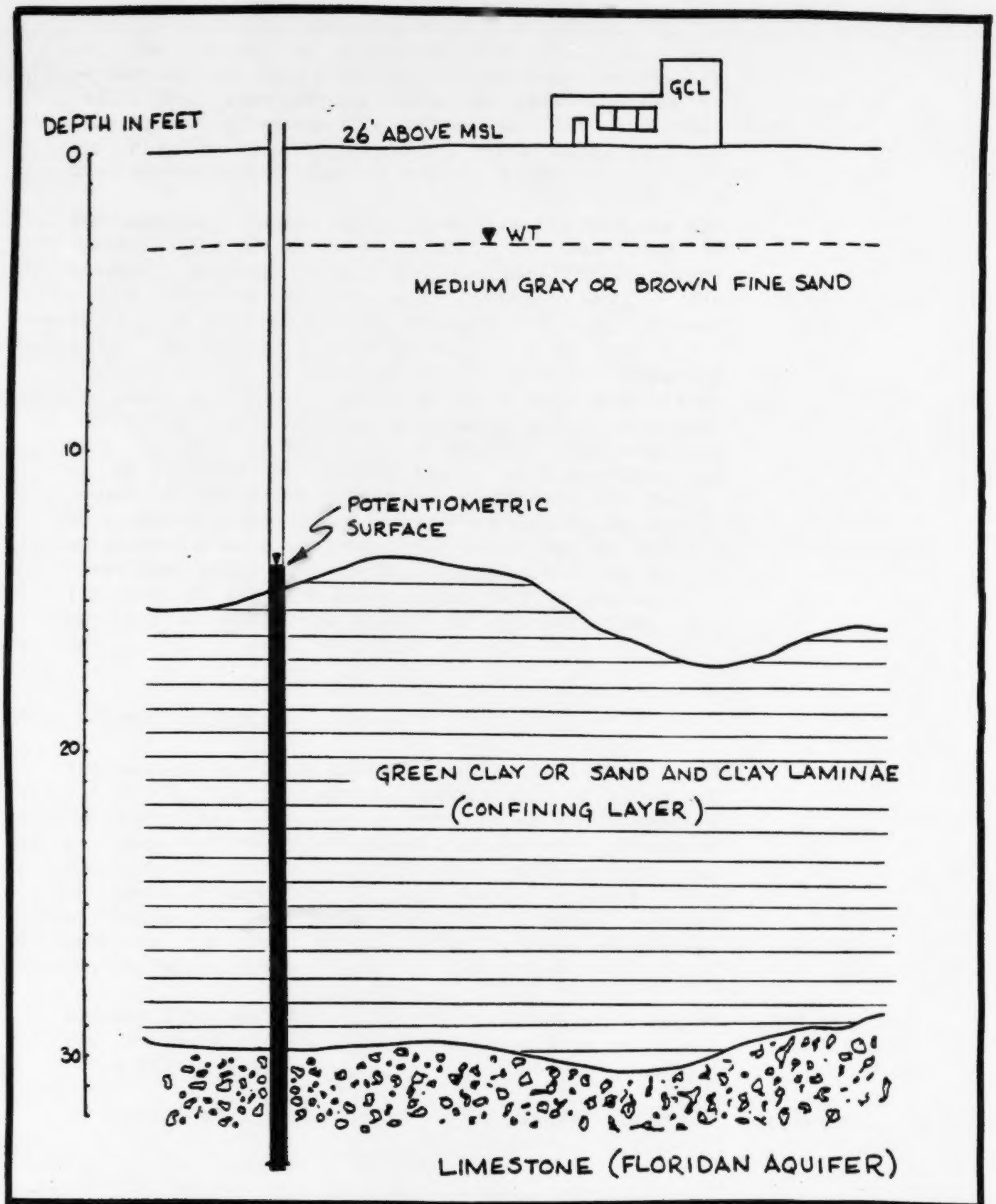
GCL
DEPTH IN FEET
26' ABOVE MSL
0
WT
MEDIUM GRAY OR BROWN FINE SAND
10
POTENTIOMETRIC SURFACE
20
GREEN CLAY OR SAND AND CLAY LAMINAE
(CONFINING LAYER)
30
LIMESTONE (FLORIDAN AQUIFER)

Figure 3. General Hydrogeologic Characteristics of the Gulf Coast Lead Site

Source: Ecology and Environment 1980

surface. The aquifer has an average transmissivity of 880 gallons per day per foot, and its storativity coefficient is 0.35. The groundwater flow in this aquifer is generally in a southwesterly direction, but the city drainage ditches tend to cause a more westerly, and sometimes northwesterly flow at the GCL site.

The confining layer, which lies directly beneath the sand layer, consists of approximately 10 feet (3m) of predominantly montmorillonite and montmorillonite-illite clay with some kaolinite and illite clay. The permeability of this clay layer averages 7.5×10^{-9} ft/sec (2.3×10^{-7} cm/sec) with a range of 1.5×10^{-8} to 2.1×10^{-10} ft/sec (4.6×10^{-7} to 6.4×10^{-9} cm/sec). Directly beneath the clay layer, about 25 to 30 feet deep (8 to 9 m), is the Floridan Aquifer, a primary source of drinking water for most of the State of Florida. The Floridan Aquifer is composed of several layers of limestone, the first three of which are called the Hawthorne, the Tampa, and the Suwannee formations, in order of increasing depth. Sloping downward in a southwesterly direction at about 3 to 5 feet per mile (0.6 to 0.9 m/km), this aquifer is artesian beneath the GCL site, where its potentiometric surface lies in about the middle of the overlying clay layer.

WASTE DISPOSAL HISTORY

The battery recovery process used at Gulf Coast Lead results in a highly contaminated wastestream of water and battery acid. The process also results in waste battery casings, composed of either plastic or rubber. Generated at between 1,200 to 1,800 gpd (4540 to 6810 l/day), the liquid wastestream has a pH below 1 and lead concentrations in the 5,000 ppm (mg/l) range. Other contaminants in this wastestream include antimony, cadmium, chromium, copper, sulfate, and nickel.

Between 1964 and 1979, both wastestreams were dumped directly on the site grounds in a central area roughly 2 acres (0.8 ha) in size.

300.64(a)(2)
identification
of source and
nature of
release

In June of 1979, GCL installed a wastewater treatment system at the direction of the State. This system reduced the lead levels in the discharge from the 5,000 ppm (mg/l) range to the 50 ppm (mg/l) range; however, GCL continued to pump this liquid directly on the ground until June 1981, the time of connection to the city sewer system.

The waste battery casings were piled above the ground, up to six casings high, at the time of the first site inspection. This visible casing pile had been reduced by approximately 60 percent by October 1980 (the time of the consent decree), and was eliminated completely during the summer of 1981. However, a 1981 investigation on the extent of contamination at the site, required by the consent decree, revealed that a large number of waste battery casings were buried within an area of 225-foot (69-m) radius and to a depth of 10-12 feet (3-4 m) beneath the old casing pile.

DESCRIPTION OF CONTAMINATION

The extent of contamination at the Gulf Coast Lead site was determined during investigations in the spring of 1981 and in the summer of 1982. These investigations revealed the presence of buried battery casings and highly contaminated groundwater in the upper aquifer at the site. The boundaries of the buried casing area, determined by about 20 borings using hollow stem augers, are shown in Figure 4. The depths of battery casings in this area range from 2 to 12 feet (0.6 to 4 m) beneath the ground surface, and the permeability of this area is several times greater than the surrounding aquifer. With the input of rainwater and battery washwater, this area became a contaminated mound of groundwater, which changed the general groundwater flow patterns in the area (Figure 5).

300.64(a)(2) identification of source and nature of release

300.67(c)(4) subsurface soil hazard

300.68(e)(2)(i)(D) hydrogeologic factors

On-site concentrations of dissolved lead in the upper aquifer range between less than 0.02 and 4 ppm (mg/l) (Figure 6); pH is between 3 and 5 units (Figure 7); and the on-site sulfate concentrations range between 60,000 to 100,000 ppm (mg/l) (Figure 8). Figures 7 and 8 also show the lateral migration patterns for two of these indicator parameters. The plume of contaminated groundwater shown in these figures was located using resistivity measurements validated by test borings. These measurements revealed a strong westerly flow pattern beyond the groundwater mound in the casing disposal area.

300.68(e)(2)(ii) extent of substance migration

The deeper Floridan Aquifer in the vicinity of the GCL site does not appear to be contaminated according to the results of several sets of samples taken from nearby residential drinking water wells.

300.68(e)(2)(i)(A) population at risk

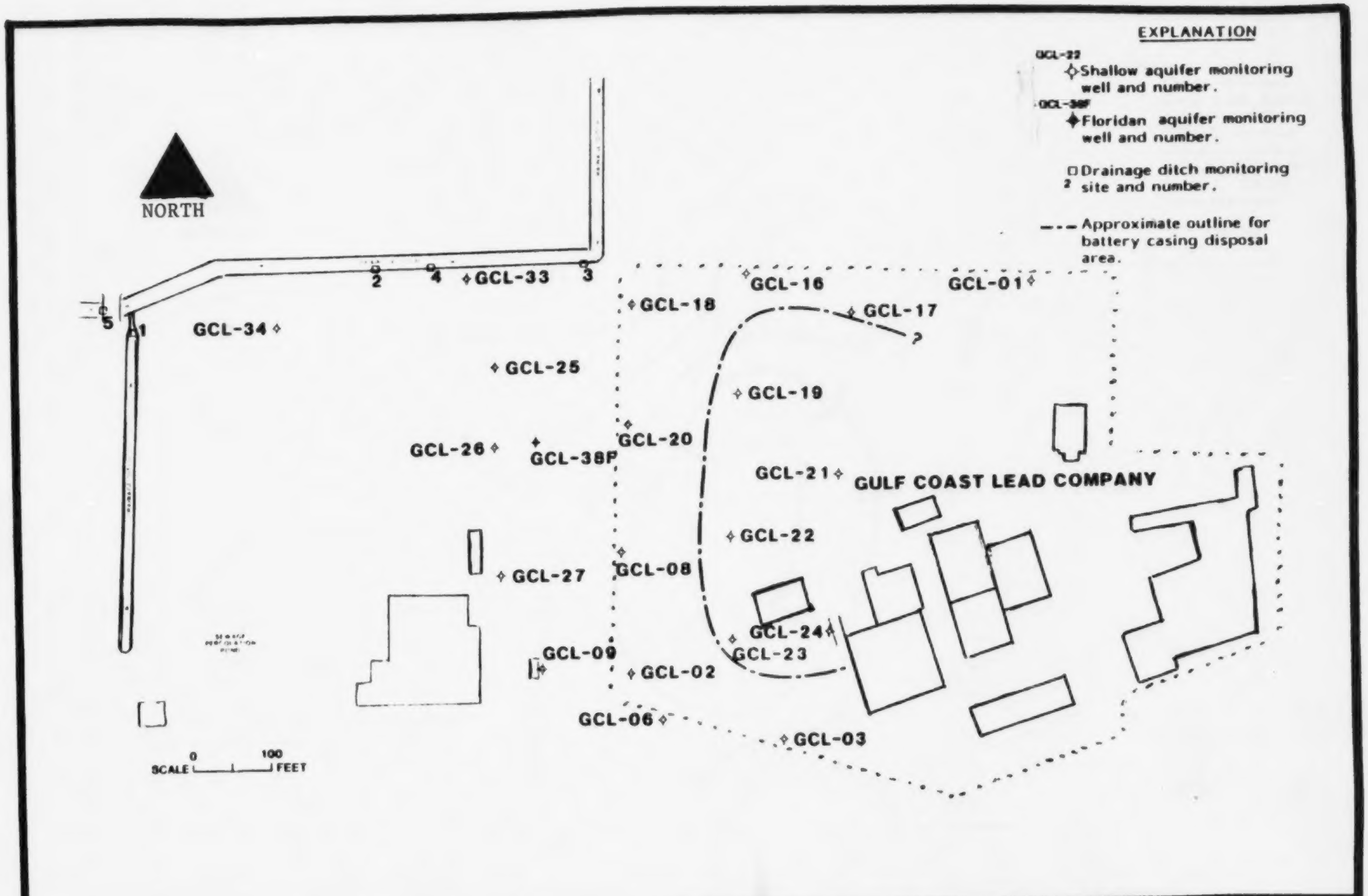

Figure 4. Approximate Boundary of the Battery Casing Area

Source: Engineering-Science 1982

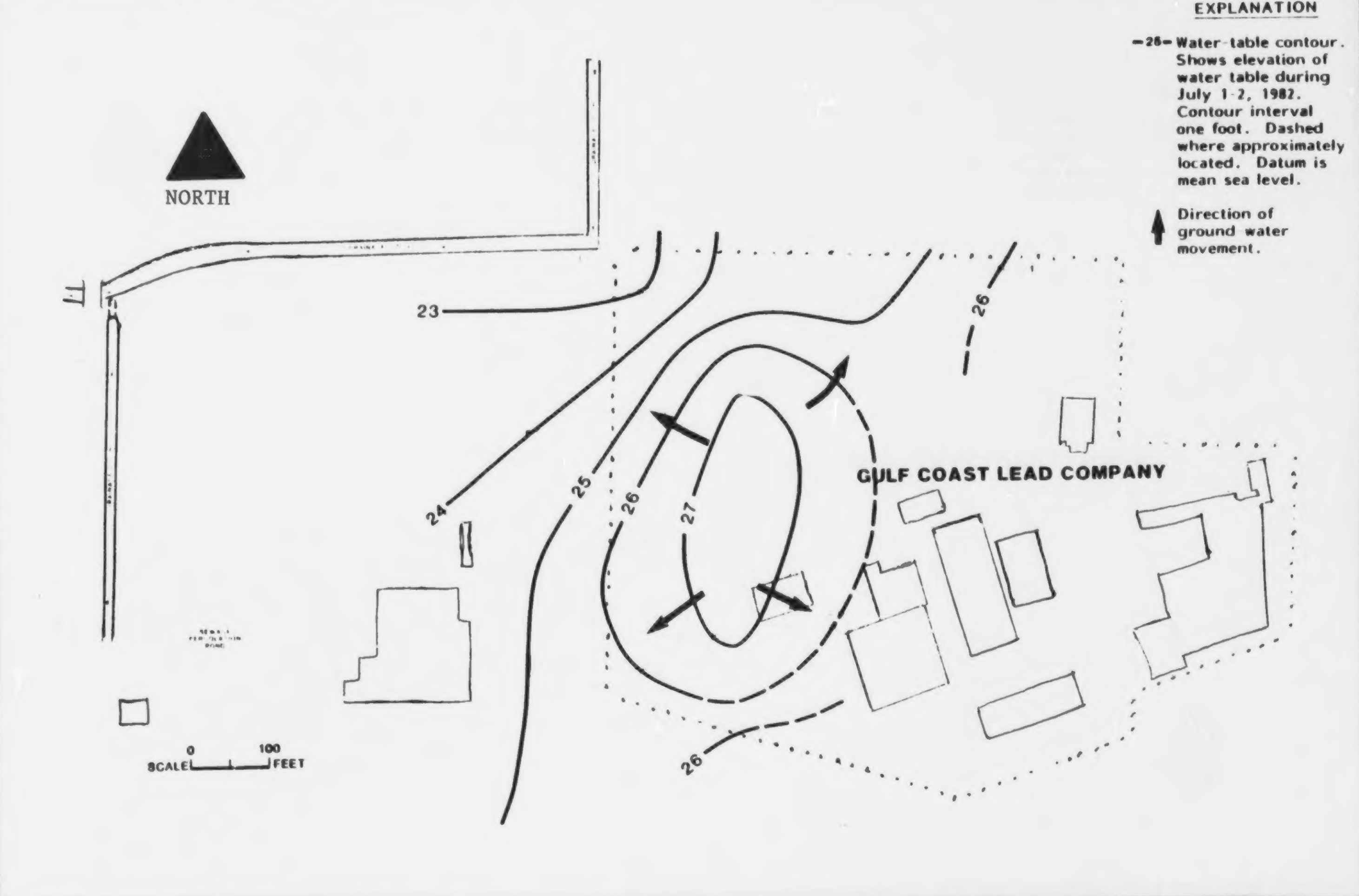
EXPLANATION
—26— Water-table contour. Shows elevation of water table during July 1-2, 1982. Contour interval one foot. Dashed where approximately located. Datum is mean sea level.
Direction of ground water movement.
NORTH
GULF COAST LEAD COMPANY
23
24
25
26
27
26
26
SCALE 0 100 FEET

Figure 5. Mounding of Groundwater in the Upper Aquifer at the Gulf Coast Lead Site Caused By Buried Battery Casings

Source: Engineering-Science 1982

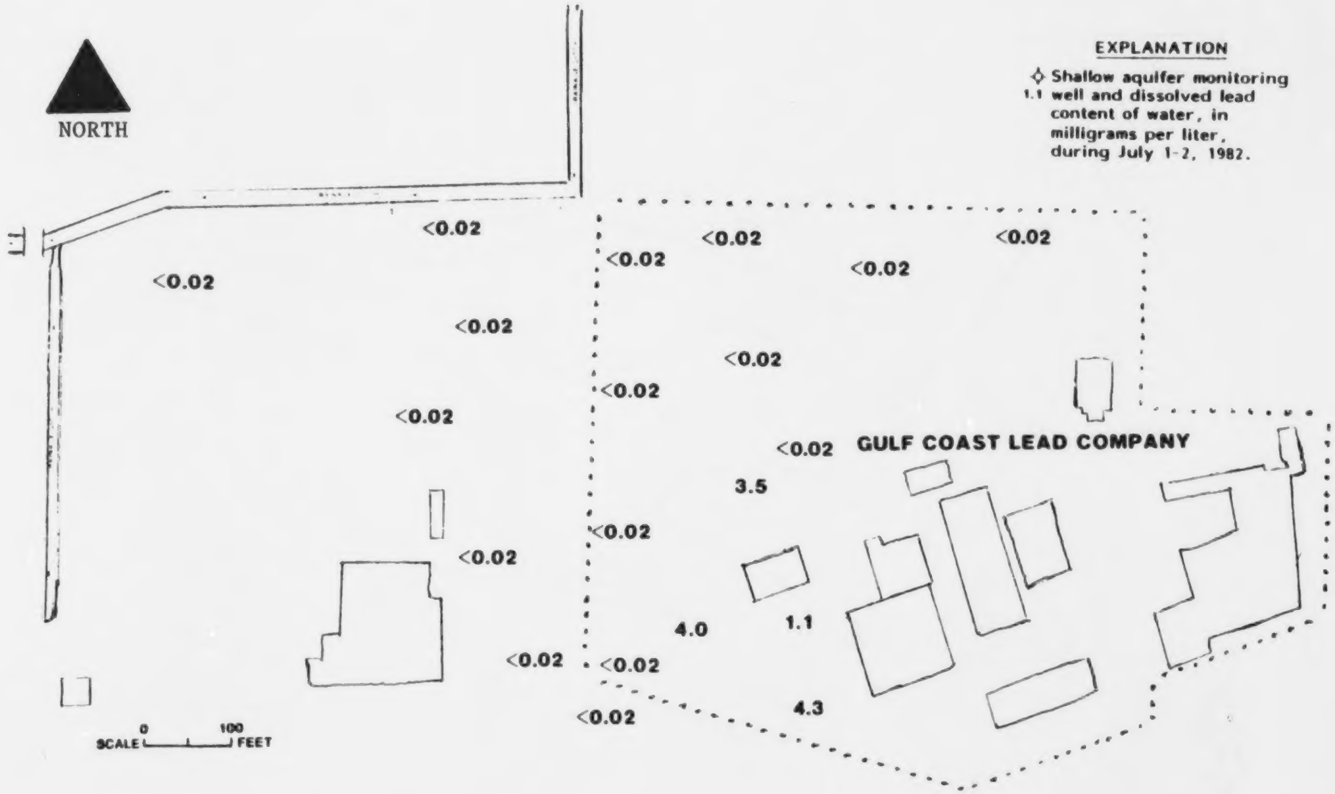

Figure 6. Dissolved Lead Concentrations in the Upper Aquifer at the Gulf Coast Lead Site

Source: Engineering-Science 1982

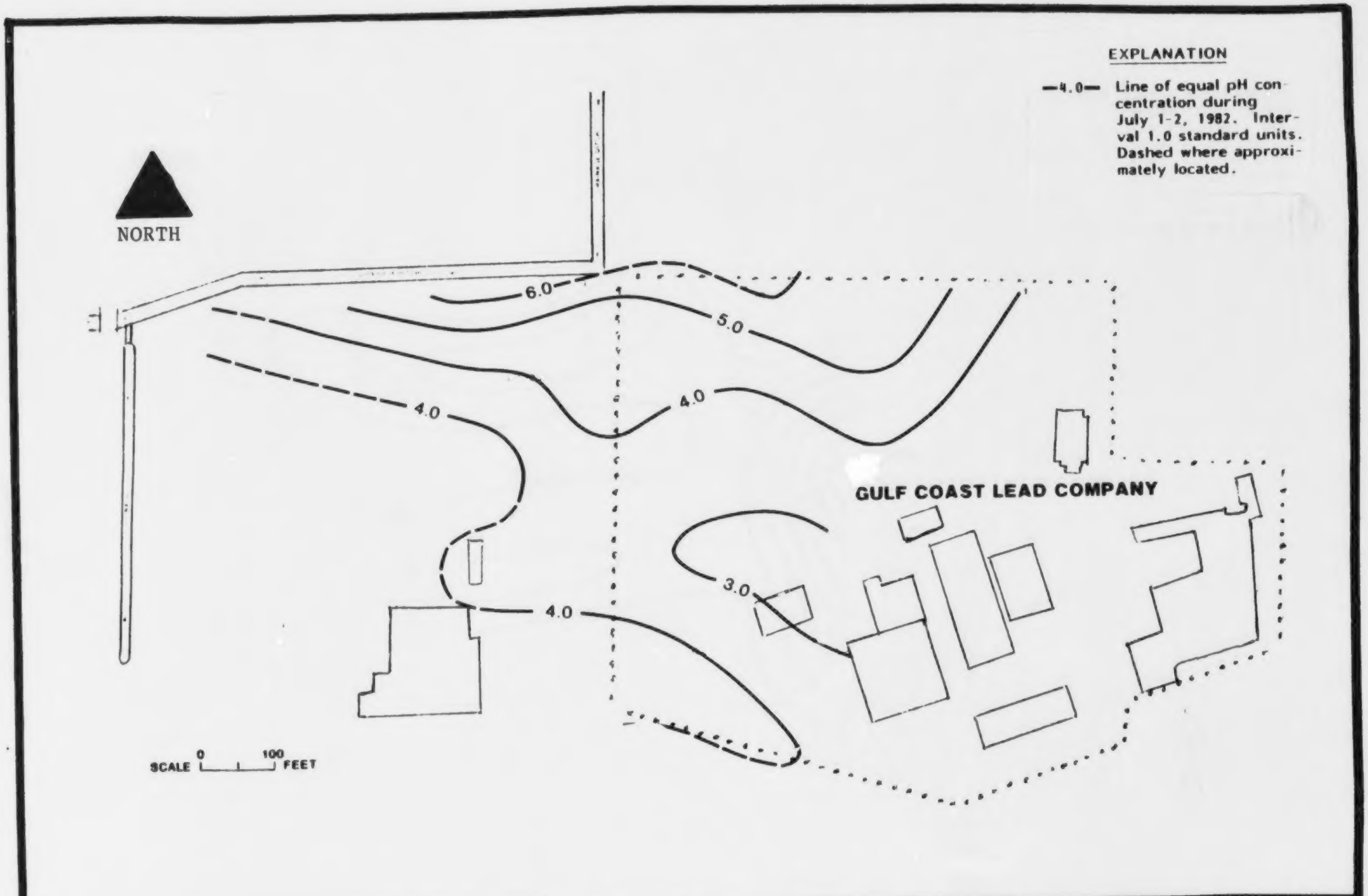
EXPLANATION
—4.0— Line of equal pH concentration during July 1-2, 1982. Interval 1.0 standard units. Dashed where approximately located.
NORTH
6.0
5.0
4.0
4.0
4.0
3.0
GULF COAST LEAD COMPANY
SCALE 0 100 FEET

Figure 7. Contour Map of pH in the Upper Aquifer at the Gulf Coast Lead Site

Source: Engineering-Science 1982

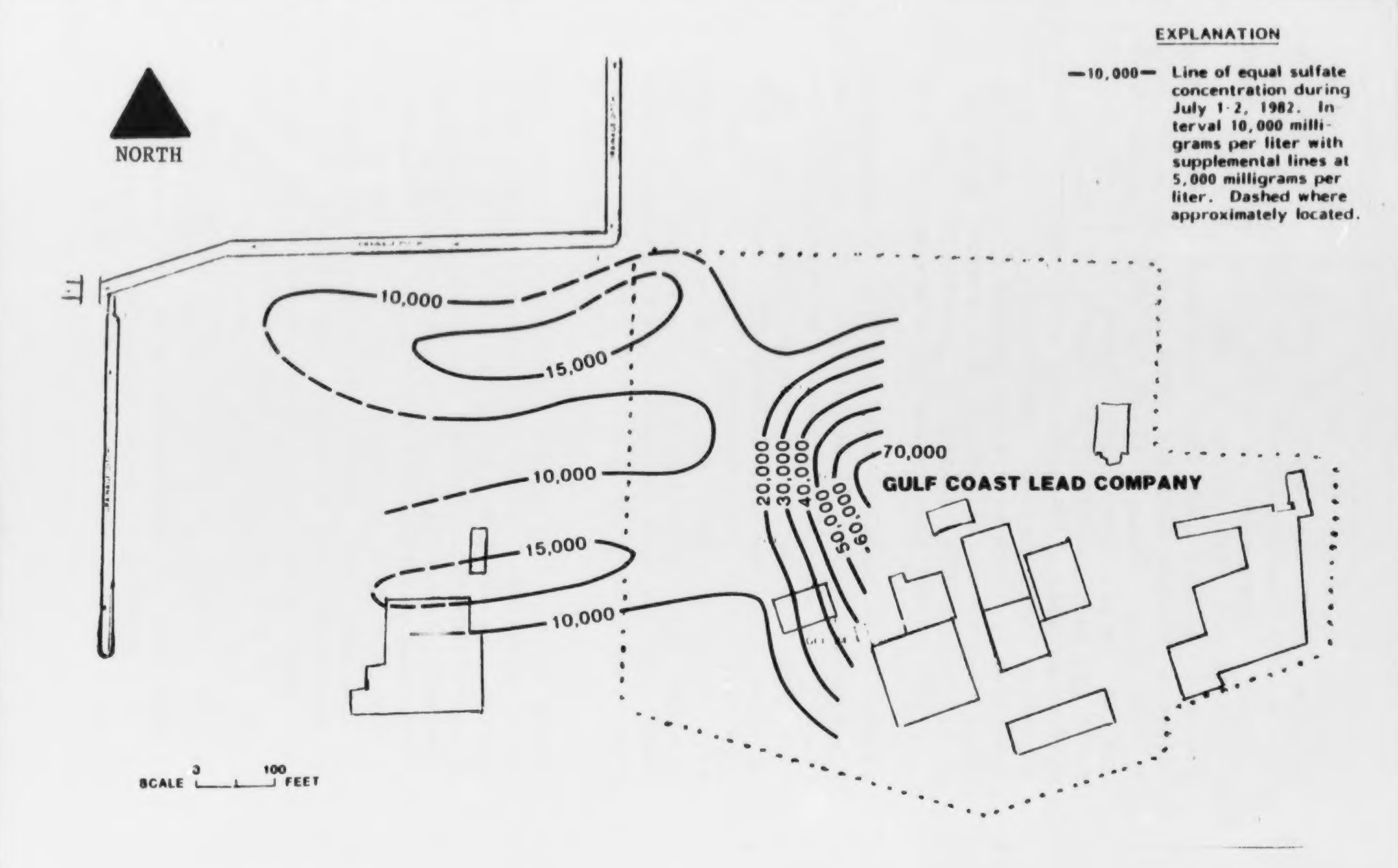
EXPLANATION
—10,000— Line of equal sulfate concentration during July 1-2, 1982. Interval 10,000 milligrams per liter with supplemental lines at 5,000 milligrams per liter. Dashed where approximately located.
NORTH
GULF COAST LEAD COMPANY
10,000
15,000
10,000
15,000
10,000
20,000
30,000
40,000
50,000
60,000
70,000
SCALE 0 100 FEET

Figure 8. Contour Map of Sulfate Concentrations in the Upper Aquifer at the Gulf Coast Lead Site

Source: Engineering-Science 1982

PLANNING THE SITE RESPONSE

Initiation of Site Response

On December 12, 1978, the HC EPC sent GCL a violation notice as a result of a recent inspection that revealed that acidic wastes were being discharged onto the ground during battery cutting operations. According to Chapter 17-4 of the Florida Administrative Code, without the benefit of any environmental controls, such actions are expected to pollute area water and thus require a wastewater permit. It was not until 6 months later that a temporary operating permit (TOP) was issued to the company. Meanwhile, in March 1979, EPA received the first of many citizen complaints regarding GCL's compliance with State water quality regulations. Because local residents were concerned that company operations might be polluting their drinking water, EPA decided to investigate. No samples were taken during an initial site inspection in June 1979, but a second visit was planned for the fall.

300.63(a)(2)
government
investigation

300.64(a)
preliminary
assessment

On November 1, 1979, the Surveillance and Analysis Division of the U.S. EPA Region IV office conducted a groundwater investigation to determine if the area groundwater was contaminated as a result of the effluent discharged at the site. The results of a report prepared in January 1980 noted that: two monitoring wells drilled on GCL property and southwest of the plant exhibited high inorganic concentrations, metals above the Maximum Concentration Levels (MCLs) under the Safe Drinking Water Act, and lowered pHs (2.4 and 3.8). No potable wells were found to be contaminated.

300.64(a)(1)
evaluation of
hazard

A preliminary assessment, conducted by EPA on February 9, 1980, noted dead and discolored vegetation in the north central area of the property. Significant amounts of lead, nickel, antimony, and sulfuric acid were found in the surficial groundwater on-site. A groundwater investigation conducted by EPA's Field Investigation Team (FIT), confirmed the source of the problem as acid infiltration from company operations and noted that although no evidence yet existed, the potential for future contamination of the Floridan Aquifer was quite high. They also said that surface runoff from the treatment area posed an immediate threat to local private water supply wells. Additionally, EPA conducted a separate on-site soil investigation on May 21, 1980 to support its theory that groundwater had been contaminated by untreated or partially treated wastewater being discharged into the shallow aquifer and/or by metals being leached from the surface into the groundwater.

300.64
preliminary
assessment
300.68(e)(2)(iv)
environmental
effects

300.66(2)
assessing migration potential
300.68(e)
extent of threat
to health, welfare,
or environment
300.67(c)
highly contaminated
soils posing a
threat

GCL's response included preparing a preliminary Plan of Study (POS) in July 1980 to evaluate and address the problem and taking the necessary steps to upgrade the GCL treatment system such that they would be able to redirect wastewater discharge into the Tampa sewer system. The area's Publicly Owned Treatment Works (POTW) requires an MCL for lead of 0.3 ppm (mg/l); while, at the time, the dissolved lead in GCL's effluent averaged 50 ppm (mg/l). State officials claimed that the company had thus far been cooperative in its effort to comply with State and local regulations as evidenced by monthly reports submitted to DER on groundwater quality from three monitoring wells (installed in 1978 by a contractor at the company's request) and the company's deep process water well. Also, officials indicated a willingess on the part of the company to begin negotiations for cleanup.

300.64(a)(3)
non-Federal party
willing to
undertake
responsibility

EPA proceeded with an enforcement action, and on October 9, 1980, filed a complaint under RCRA Section 7003 requiring GCL to stop discharging contaminated wastewater in a manner that presents an imminent and substantial endangerment; to determine the extent of contamination; and to clean up the hazardous waste on its property. Three weeks later, on October 31, 1980, a partial consent decree was signed. The agreement included five specific tasks with respective deadlines for each:

1. Continue reducing lead concentrations in GCL wastewater to a level acceptable to Tampa for discharge into its sewage treatment plants (8 months)

2. Submit a Plan of Study (POS) to describe the means the company will use in determining the extent of soil and groundwater contamination attributable to GCL plant operations (30 days)

3. Prepare a full report on the extent of contamination (60 days after approval of POS)

4. Develop and implement a Remedial Plan (RP) based on the Report (concurrent with report)

5. Develop a Contingency Remedial Plan (CRP) to address off-site problems (concurrent with RP).

On November 28, 1980, GCL submitted a POS that was approved on February 11, 1981. By June 15, 1981, the company had completed hookup with the city's sewer system. Four days later, they submitted a Report on Contamination accompanied by a first draft Remedial Plan. Agreement was reached and approval granted in July 1982 for the first Remedial Plan. On December 7, 1982, EPA approved the revised, final Remedial and Contingency Remedial Plans.

Selection of Response Technology

The consent decree between EPA and GCL required that the remedial technologies employed at the GCL site must either eliminate or isolate and contain all hazardous constituents in the soil and the groundwater that are attributable to GCL operations. Table 1 presents the technologies that were considered by GCL and EPA to address the problems at the site in accordance with the requirements set forth in the consent decree. These technologies were integrated into three basic response plan alternatives, which included:

300.68(h)
initial screening
of alternatives

- Capping the contaminated area combined with a stormwater management system
- Capping and stormwater management combined with a bentonite-cement slurry wall downgradient from groundwater flow
- Capping and stormwater management combined with groundwater withdrawal and treatment.

Capping of the site was considered to be an essential part of the response because it would greatly reduce the off-site transport of contaminants by preventing the direct infiltration of rainwater into the highly permeable battery casing disposal area. (A stormwater management system had to be included with capping to address the increased surface runoff associated with reduced rainwater infiltration). However, capping alone would not prevent the off-site contaminant migration caused by groundwater movement through the site. Capping combined with a downgradient barrier would further isolate the on-site contamination; however, laboratory tests showed that the high dissolved solids levels at the GCL site may inhibit the swelling characteristics of a bentonite slurry wall.

The selected remedial plan of capping combined with groundwater withdrawal and treatment was selected because it provided the greatest assurance that the threat of further contamination in the vicinity of the GCL site would be eliminated. This remedial plan was later

TABLE 1. ALTERNATIVE RESPONSE TECHNOLOGIES CONSIDERED AT THE GULF COAST LEAD SITE

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP Reference
Slurry Wall	Bentonite cut-off wall to contain contaminated groundwater.	Rejected because high dissolved solids in the contaminated plume would have inhibited the swelling characteristics of the bentonite.	300.70(b)(1)(iii)(A)(1) slurry walls
Surface Seals	Compacted clay in one area and asphalt in another area to be used as parking lot.	Capping was chosen to prevent infiltrating rainwater from accelerating the off-site movement of contaminants and to reduce the pumping rate needed to reverse the hydraulic gradient in the area of contamination.	300.70(b)(1)(ii)(A) surface seals
Groundwater Pumping	Seven well points in the area of severe contamination (Phase I wells) and 20 well points downgradient from the source of contamination (Phase II wells). Phasing of the pumping program was recommended to prevent unnecessary migration of contaminants downgradient.	Well points were chosen because the extraction of groundwater contaminants was environmentally desirable, unquestionably feasible, and could be done at a reasonable cost.	300.70(b)(1)(iii)(C) groundwater pumping

(continued)

TABLE 1. (continued)

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP Reference
Surface Water Diversion and Collection Systems	A lined lagoon with berms and pumping stations for collecting contaminated runoff, and a rainwater diversion/underdrain system for discharge of uncontaminated rainwater.	This system was necessary to accommodate the increased runoff caused by the surface sealing at the site (see above).	300.70(b)(1)(ii)(B) surface water diversion and collection systems
Neutralization	Contaminated groundwater from counterpumping program (see above) is treated with lime and caustic soda to adjust pH and precipitate heavy metals.	The neutralization system was needed to meet discharge standards for the City of Tampa sewer system.	300.70(b)(2)(iii)(E)(2) neutralization
Reaction Barrier*	A deepened drainage ditch downgradient from the contaminated groundwater plume. The ditch is filled with lime and crushed oyster shells to elevate the pH and reduce the soluble metals in the plume.	This system was recommended to treat any contaminants that may escape the groundwater pumping and treatment systems (see above).	300.70(b)(1)(iii)(D)(1) subsurface drains

*Not considered until suggested by EPH at July 1982 meeting.

augmented, through negotiations with the EPA, by the addition of an "acid reaction barrier" to intercept and neutralize any contaminated groundwater that had already migrated off-site. The barrier is to be located west of the site and will consist of a deep trench filled with oyster shells and crushed limestone.

Extent of Site Response

The specific objectives for the remedial response were as follows:

300.68(j)
extent of remedy

1. To successfully isolate and contain hazardous contaminants found in the soil and the shallow groundwater beneath the GCL site
2. To withdraw shallow groundwaters from beneath the GCL site containing hazardous contaminants for treatment and disposal in accordance with RCRA
3. To establish a permanent long-term groundwater monitoring system
4. To mitigate off-site effects of possibly contaminated groundwater by the installation of a subsurface reaction barrier containing crushed mineral carbonate.

The remedial plan will be considered "successfully implemented" when a certain numerical water quality level is achieved for all wells on-site. Parameters for this cleanup effort were based on EPA water quality criteria under Section 304(a) of FWPCA. Specifically, pumping and treating the groundwater must continue until the concentration of lead reaches 0.05 ppm (mg/l) and the pH is elevated to background level or 6.0 standard units, whichever is higher. When this objective is achieved, continuous withdrawal may halt, but monitoring will continue. If lead concentrations should rise above the 0.05 ppm (mg/l) level or the measured pH falls below background, the entire pumping system, including the 20 "Phase II" wells located along the periphery, will be activated as is necessary to reduce the lead and the acidity to the established criteria. Additionally, the Phase II wells will be used if contamination is found off-site. Monitoring will continue for 30 years unless, after 10 years, GCL can demonstrate that pumping and treatment is no longer needed to assure successful isolation and containment of hazardous contaminants. No time limit was set for meeting these standards, but GCL's consultants estimated that at least 2 years will be required for one turnover of the contained fluids in the battery case area.

The issue of when to cease pumping entailed months of negotiations. The GCL company preferred to end the pumping and treatment program when they achieved no observable change in water quality. EPA wanted finite numbers, i.e., 0.05 ppm (mg/l) and a specific pH level, to indicate that pumping and treatment is no longer necessary.

DESIGN AND EXECUTION OF SITE RESPONSE

The final remedial plan for GCL was accepted by EPA in December 1982 and consisted of the following remedial technologies:

• An earthen cap over part of the unpaved area of the site and an asphalt cap over the remainder	300.70(b)(1)(ii)(A) surface seals
• A surface water control system to accommodate the increased rainwater runoff caused by capping the site	300.70(b)(1)(ii)(B)(2) ditches, diversions, waterways
• A groundwater withdrawal and treatment system	300.70(b)(1)(iii)(C) groundwater pumping
• A long-term groundwater monitoring program	300.70(b)(2)(iii)(E)(2) neutralization
• A subsurface acid reaction barrier.	300.70(b)(1)(iii)(D)(1) subsurface drains

The design and the installation of these technologies at the GCL site are described below.

Capping

The objective of this remedial technology at the GCL site was to prevent any further infiltration of rainwater. Therefore, all unpaved areas at the site were capped with either asphalt or clay. The clay cap was placed over a 3.44-acre (1.4-ha) area of the site overlying the buried battery casings (Area 3 in Figure 9). This cap consisted of a 4-inch (10-cm) layer of clay, compacted with a bulldozer, over the existing grade followed by 8 feet (2.4 m) of topsoil and grass sod.

300.70(b)(1)(ii)(A)
surface seals

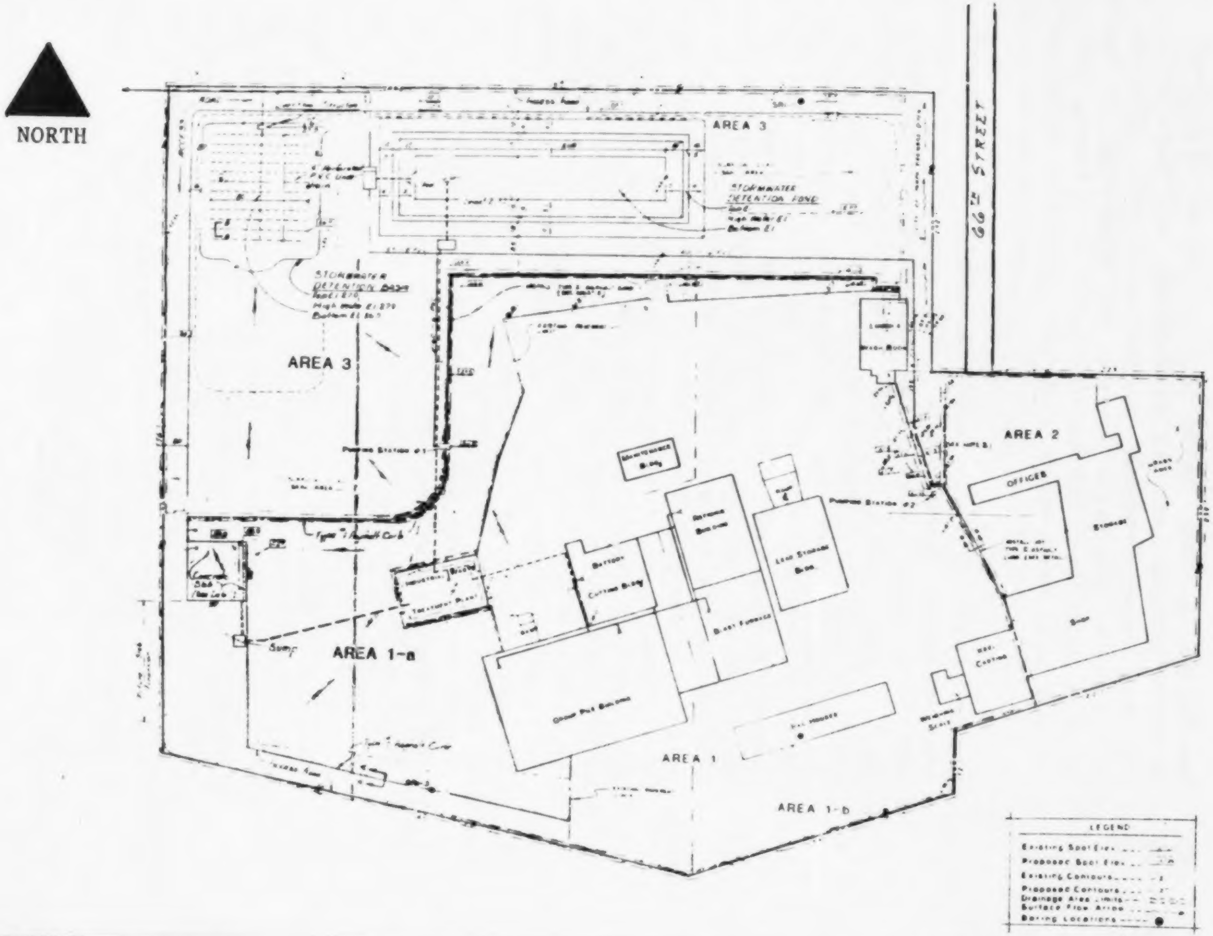

Figure 9. Map of the Gulf Coast Lead Site Showing the Stormwater Management System, the Industrial Waste Treatment Plant, and Clay and Asphalt Capping Areas

Source: Environmental Engineering Consultants 1982b

An asphaltic cap was placed over the remaining 1.28 acres (0.5 ha) of unpaved ground at the site (Area 1-a in Figure 9). This area was not capped with clay because the GCL Company wanted to use it for heavy trucks. This cap consisted of 1.5 inches (4 cm) of asphalt applied over an 8-inch (20-cm) layer of limerock base material.

Surface Water Controls

300.70(b)(1)(ii)(B)
ditches, diversions,
waterways

The need for a surface water control system was recognized upon the decision to cap the unpaved areas of the GCL site. Prior to capping, surface runoff had been allowed to run toward the unpaved areas and to percolate into the ground. If site capping had been done with no surface water controls, the site would have been flooded after a few rain events.

The design of the surface water control system included two main components: a stormwater retention pond and a stormwater detention basin (see Figure 9). The stormwater detention pond covers 8360 square feet (777 m^2), is lined with 0.036 inches (.09 cm) of reinforced chlorinated polyethylene, and has a capacity of 281,400 gallons (1.06 x 10^6 l). It receives all rainwater falling on the paved areas of the GCL plant through 6-inch (15-cm) PVC pipes connected to two pumping stations. In addition, the pond receives runoff from sprinkling systems located on all buildings in the production area. These sprinklers are activated automatically several times a day for dust suppression. The water collected in the pond (called graywater) is recycled for use in the sprinklers and battery case washing system. However, the pond is equipped with an overflow pipe to the city's storm ditch for use in the event of an unusually heavy rain period. Buildup of contaminants in the recycled water is not a problem, since about 15,000 gallons per day (56,780 l/day) of fresh water must be added to the system to replace the water that is treated and discharged to the city sewer system.

The stormwater detention basin is designed to collect surface runoff from the clay cap for conveyance to the city storm ditch, which parallels the northern boundary of the GCL site (Figure 10). The detention basin is composed of approximately twelve, 85-foot (26-m) long, 4-inch (10-cm) diameter perforated PVC pipes arranged in parallel on 8.5-foot (2.6-m) centers. These 12 pipes are connected together in the middle by another PVC pipe running perpendicularly toward an overflow structure.

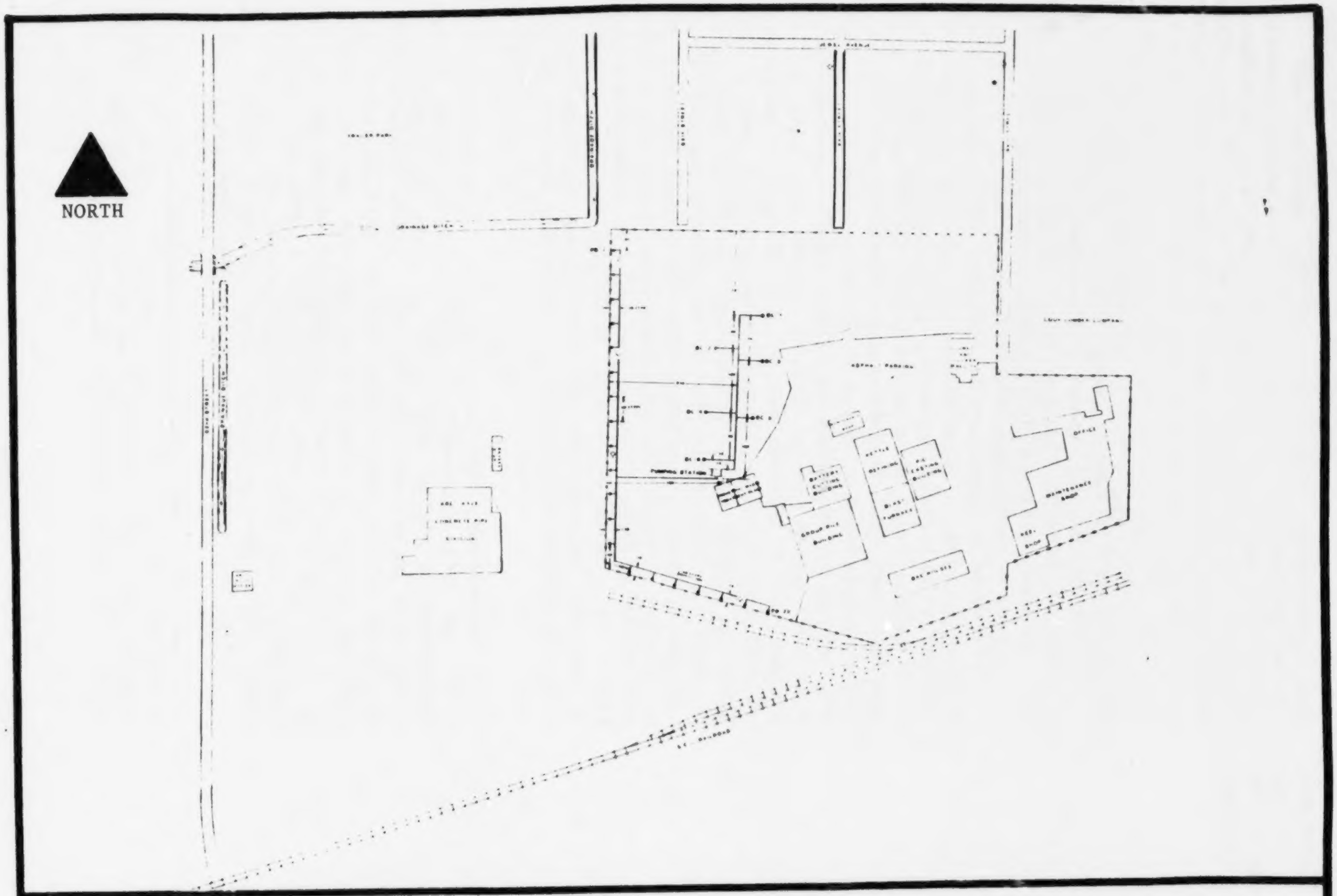

Figure 10. Groundwater Withdrawal Wells Along the Western and Southwestern Boundary and in the Battery Casing Disposal Area of Gulf Coast Lead Site

Source: Engineering-Science 1982

Groundwater Withdrawal and Treatment

300.70(b)(1)(iii)
(c)
groundwater
pumping

The purposes of the groundwater withdrawal and treatment system are: (1) to contain (by reversal of the groundwater gradient) the off-site migration of contaminants; and (2) to eliminate the sources of the contamination. The selection of these technologies necessitated the identification of the most appropriate areas to withdrawal groundwater, and the assessment of the hydraulic properties of those areas. These areas were located directly above the battery casing disposal area and along the western and southwestern boundaries of the GCL site. The battery casing area was selected because it was the source of groundwater contamination, thus pumping this area would result in the quickest improvements in groundwater quality. The western and southwestern boundaries of the site were selected for groundwater withdrawal because pumping these areas would intercept contaminated groundwater flowing off the site and because this pumping would draw off-site contaminated groundwater into the treatment system. The pumping of these areas is scheduled to occur in two phases. Phase 1 will be conducted in the battery casing area and Phase 2 will occur along the site boundaries. Phase 2 will be implemented if the Phase 1 pump is shut down for maintenance. Phase 2 will also be implemented if Phase 1 pumping fails to produce at least 15 gallons per minute, or if the groundwater gradient is not reversed beyond the GCL boundary by Phase 1 pumping. Phase 2 may never be implemented if Phase 1 results in the achievement of the groundwater quality objectives (i.e., $\leq$ 0.05 ppm (mg/l) of lead and a pH of $\geq$ 6). This phased approach to groundwater pumping was selected to prevent further migration of contaminants toward the site boundary.

The hydraulic properties of the groundwater withdrawal areas were studied in December 1981 by GCL's contractor, and again in July 1982 by EPA's contractor. These studies showed that the battery casing area had a high transmissivity (184,000 gallons per day per foot) and a high average storage coefficient of 0.7. However, because of the non-homogeneous nature of this area, it is possible to pump a given well dry at a low rate of withdrawal. The average groundwater flow rate away from the battery disposal area, including rainwater infiltration, was 7000 gallons per day (26,500 l/per day).

After the placement of a clay cap, the EPA study estimated that a withdrawal rate of 3 gallons per minute (11 l per minute) would be sufficient to: (1) prevent migration of contaminated groundwater from this area.

However, the minimum rate of pumpage from this area was established at 15 gallons per minute (57 l per minute) to accelerate cleanup (while remaining below the maximum discharge rate allowed by the City of Tampa). The GCL Company and EPA agreed that, despite this low rate of required pumping, seven withdrawal wells should be placed in the battery casing area because there is a possibility of pumping some of the wells dry. These seven wells were constructed of 4-inch (10-cm) diameter PVC pipe with 2-inch (5-cm) diameter feed pipes. The wells are all screened just above the clay confining layer and are connected by an above-ground manifold (see Figure 10). It was decided to pump these wells individually because of the difficulty of regulating the pumping rate when operating all seven wells simultaneously.

The groundwater withdrawal area at the western and southwestern boundaries of the GCL site was found to have a transmissivity of 680 gallons per day per foot and an average storage coefficient of 0.17. These findings were used to design and place 20 2-inch (5-cm) diameter PVC well points, spaced along the GCL boundary lines on 40-foot (12-m) centers (see Figure 10). These wells are all screened at a depth of 10 feet (3 m), just above the clay aquitard, and each well will be pumped at 0.75 gallons per minute (3 l per minute) if pumping rates are too low in the battery casing area. These pumping rates will create a 15 gallon per minute (57 l per minute) input to the treatment system and are expected to create approximately 1 foot (0.3 m) of drawdown at a distance of 230 feet (70 m) beyond the site boundary after 100 days (Figure 11).

The groundwater treatment system at the GCL site is the same system used for the treatment of process wastewater. It consists of primary clarification followed by pH adjustment (using lime or caustic soda), and final clarification. The system reduces lead concentrations from 6 ppm (mg/l) to below 0.3 ppm (mg/l) and adjusts the pH from 1.5 to 9.7. The city requires that lead concentrations in the effluent be below 0.3 ppm (mg/l). The city also limits the volume of discharge from the treatment system to 20,000 gallons per day (75,700 l per day).

300.70(b)(2)(iii)
(E)(2)
neutralization

Groundwater Monitoring

The groundwater monitoring program at the GCL site was designed to detect any unexpected migration of contaminants within the upper aquifer and to detect any downward movement of contaminants into the Floridan Aquifer. These objectives are being met through quarterly

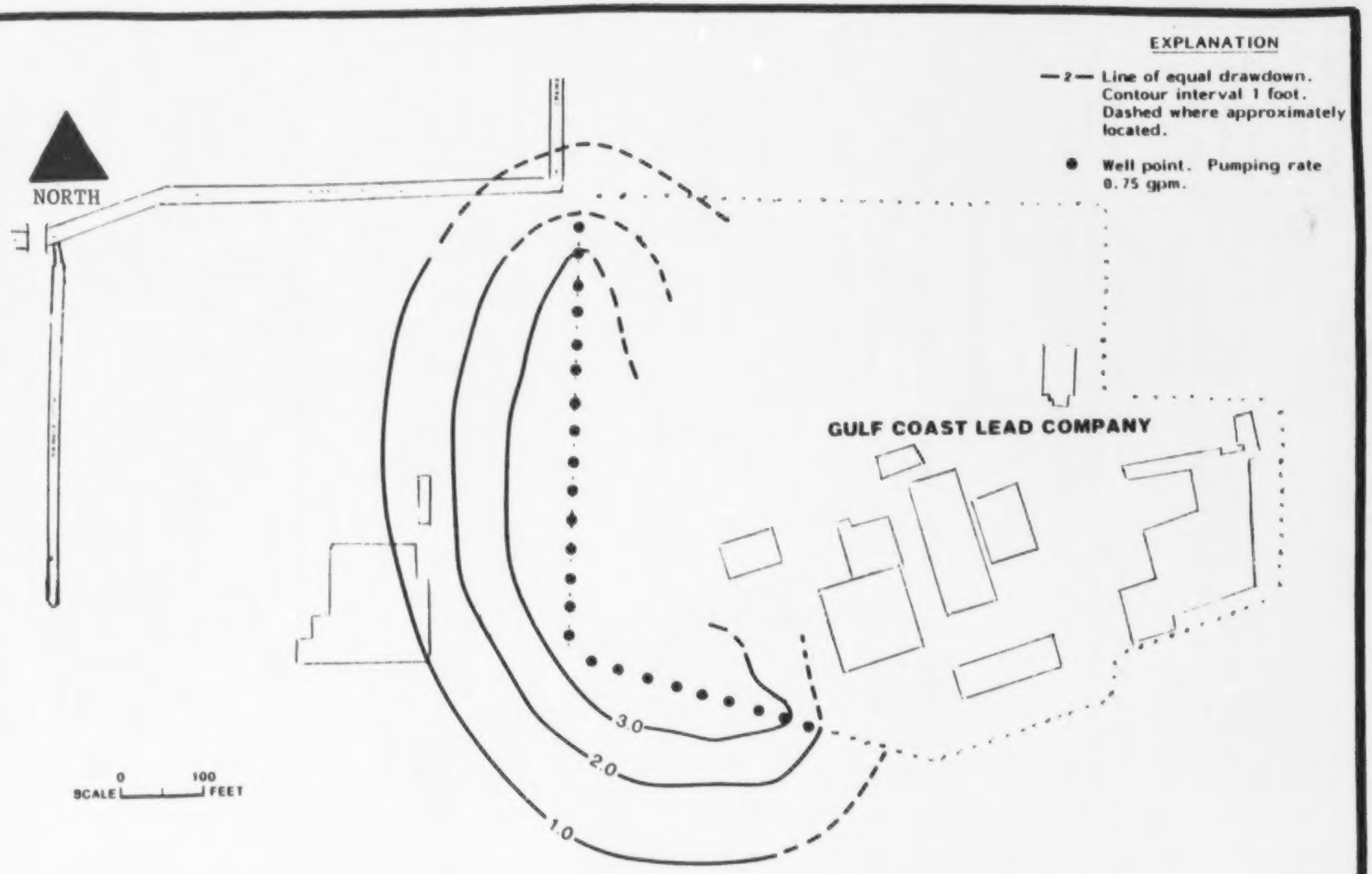
EXPLANATION
—2— Line of equal drawdown. Contour interval 1 foot. Dashed where approximately located.
● Well point. Pumping rate 0.75 gpm.
NORTH
GULF COAST LEAD COMPANY
3.0
2.0
1.0
SCALE 0 100 FEET

Figure 11. Amount of Drawdown Expected in the Upper Aquifer at the Gulf Coast Lead Site After 100 Days of Pumping at 15 GPM

Source: Engineering-Science 1982

samples of 6 upgradient and 21 downgradient wells at the site. The samples are analyzed for lead, pH, sulfate, and specific conductance. The upgradient wells (numbers 13, 14, 15, and 12F) are all within the upper aquifer except for Well 12F, which is screened at a depth of 65 feet (20 m) within the Floridan Aquifer (Figure 12). Two of the downgradient wells (38F and 39F) are located in the Floridan Aquifer, screened at depths of 54 and 58 feet (16 and 18 m), respectively.

Monitoring of these wells has not shown any significant trends; however, the groundwater withdrawal program began in March 1984, only 2 months before this report was completed.

Subsurface Acid Reaction Barrier

This barrier was the only part of the remedial plan that had not been implemented at the time of this writing. Tests are presently being conducted to determine the proper depth and placement of this barrier.

300.70(b)(1)
(iii)(D)(1)
subsurface
drains.

COST AND FUNDING

Source of Funding

All project costs were paid by Gulf Coast Lead Company.

300.68(c)
responsible party
funding

Selection of Contractors

Gulf Coast Lead's two primary consultants, Environmental Engineering Consultants, Inc. and Seaburn and Robertson, Inc., were selected based on their experience, qualifications and reputation, while formal competitive bidding was used for the selection of all other contractors to provide assistance during the response effort at GCL.

Environmental Engineering Consultants, Inc. (EEC) was selected by GCL to help design the remedial plan in the spring of 1981. This firm was selected because it was run by a former consultant to GCL who was familiar with the plant operations. Seaburn and Robertson, Inc. (SRI) of Tampa was chosen as the company's groundwater consultants based on a recommendation from EEC. For work on the impermeable surface seal, GCL used various local companies, including Jerry Blankenship Trucking, Big John's Excavating, Garner Asphalt Paving, Art's Sprinkler and Pumps, and Keene Brothers Trucking. Each of these contractors was hired after GCL went through regular

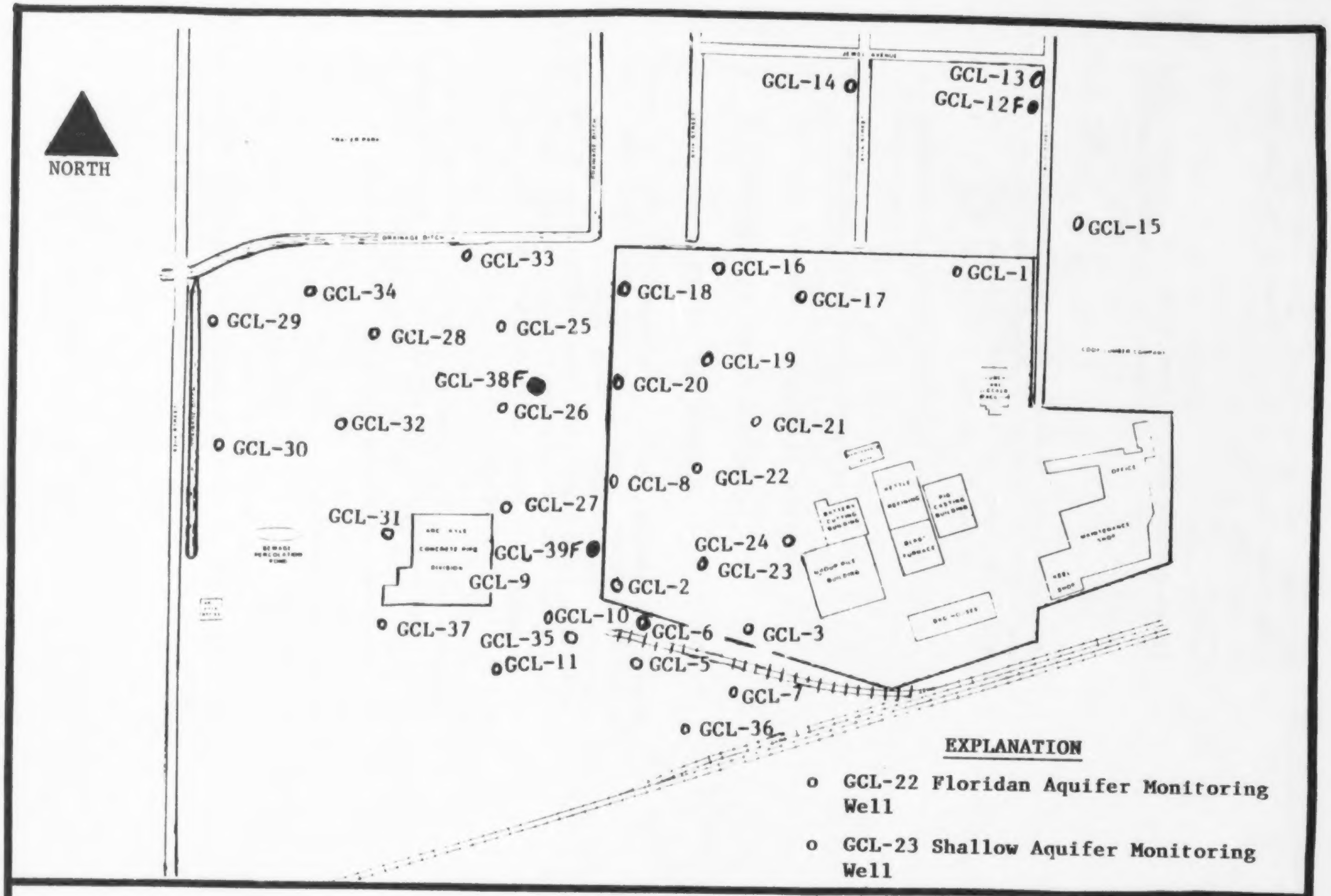

Figure 12. Location of Groundwater Monitoring Wells at the Gulf Coast Lead Site

Source: Seaburn and Robertson 1981

bidding procedures in which the lowest qualified bidder was selected. The same process applied to Mixon Foundation and Drilling, responsible for installing the recovery wells and well points; Moretrench American, Corp., who provided all of the plumbing services included in the groundwater recovery system; Palco Linings, Inc., for the surface water retention system; and Fancher Electric Company, for work done on the pumping stations in the stormwater management program.

Project Cost

The total cost of the remedial response was about $700,000, including research, capital, design, and construction. The general categories that are discussed below and tallied in Table 2 are as follows:

A. Hydrological Investigation and Consultant Services

B. Stormwater Management Program

C. Shallow Groundwater Recovery System

D. Wastewater Treatment Facility

E. Groundwater Monitoring Program.

Some of these categories include expenditures made between 1980 and 1982 for short-term remedial actions that the company initiated prior to the consent agreement and for which no detailed cost breakdowns were available. Certain other costs were not recorded by GCL as expenses directly related to the remedial plan, although these costs were a component of the response effort. For example, up through December 1981, GCL had spent $140,716.67 on their chemical treatment facility, although the Remedial Plan was not officially approved until the end of 1982. Moreover, this total was not broken down by category for research and development, labor and parts, or capital design. Also excluded from the total calculated for Gulf Coast Lead is analytical equipment purchased before January 1982, the salary of the Quality Control Technician, the cost of in-house analyses, and a per gallon or total cost for treating wastewater for the entire period in question. However, sources did note that for each ton of lead, it costs the company $20 to treat the waste battery acid.

The total cost shown above does include $120,000 for all legal expenses in regard to the suit and consent agreement, as well as $45,000 for the salary of the Safety

TABLE 2. SUMMARY OF PROJECT COSTS - GULF COAST LEAD COMPANY, TAMPA, FLORIDA

Task	Quantity	Estimate	Actual Expenditure	Period of Performance
A. Hydrological Study and Consultant Services	--	--	$ 96,457.61	
Groundwater	--	--	(51,905.86)	1980-1982
Engineering	--	--	($ 44,551.75)	1981-1983
B. Stormwater Management Program	--	$255,000.00	$214,883.42	4/26/83-11/1/83
1. Impermeable Surface Seal	5.6 acres	($169,000.00)	($146,045.28)	
2. Surface Collection System	--	($ 74,000.00)	($ 53,110.52)	
3. Pumping Stations	2	($ 12,000.00)	($ 15,727.62)	
C. Shallow Groundwater Withdrawal Program	--	--	$ 44,192.59	6/83-3/84
1. Installation	7 wells, (4" diam.)	--	($ 8,450.00)	
2. Plumbing and Other Labor	20 wells, (2" diam.)	-- --	($ 7,000.00) ($ 28,742.59)	
D. Wastewater Treatment Plant	--	--	$151,307.57	
1. Original Construction	--	--	($140,716.67)	12/79-12/81
2. Required Upgrading	--	--	($ 10,590.90)	9/82-10/83
E. Groundwater Monitoring Program	--	--	$ 30,031.00	--
1. Installation	20 wells, various sizes	--	($ 16,210.00)	1981
2. Chemical Analyses	--	--	($ 3,821.00)	1981
3. In-house Analyses	--	--	($ 10,000.00)	1984
F. Other			$165,000.00	
1. Legal Expenses	--	--	($120,000.00)	1980-1983
2. GCL Staff	--	--	($ 45,000.00)	1981-1984
TOTAL			$701,872.19	

Source: Gulf Coast Lead 1984

and Environmental Director at Gulf Coast Lead. This second figure is calculated on the basis of devoting to the response effort 70 percent of the Director's billable hours in 1981 and 1982, 50 percent in 1983, and 20 percent in 1984, excluding benefits, etc.

All information is based on actual goods and service costs between 1980 and 1984 drawn from company balance sheets and from estimates by senior staff at GCL. Total equipment and labor expenses for implementing the response were taken directly from these sources. However, in order to develop task-specific subtotals, it was necessary to make best judgments while allocating the materials and the labor costs to the different response actions. These subtotals are shown in Table 2.

Hydrological Study and Consultant Service

A total of $68,115.86 was paid to Seaburn and Robertson, Inc. between the fall of 1980 and March 1982 for its professional services, geotechnical services, and for all costs incurred for materials and subcontractors as the company's groundwater consultants. This cost covered payment for four major tasks:

- Preparing the Plan of Study in November 1980
- Developing a detailed Report on Contamination in June 1981
- Developing a preliminary monitoring program in 1981
- Testing and reporting on the results of an aquifer study in March 1982.

Of these tasks, no breakdown for capital design, labor, hydrologic investigations, or other studies was available. The only cost separated out was $16,210 for installation of 20 monitoring wells in a preliminary monitoring program. For purposes of consistency, this cost was added in the total for the present groundwater monitoring program.

A total of $44,551.75 was paid to Environmental Engineering Consultants between 1981 and October 1983. This cost was for various tasks and included designing the Remedial and Contingency Remedial Plans, the Stormwater Management Program (the first effort in 1981 and then an expanded, final version in 1983) and an operating plan for the well recovery system. They also performed aquifer tests and inspected and supervised construction activities during the response effort. During 1983, total expenses for EEC amounted to $28,356.75 and in 1982, $8,645 for work at GCL. The total in 1981 was $7,540.

Stormwater Management Program

Gulf Coast Lead Company spent over $200,000 on capital and construction costs for this program. Table 3 offers a detailed description of the total costs for these projects. This total was broken down into three projects: the surface seal, the surface water collection system, and a pair of pumping stations. The surface seal, at $146,045.28 was the largest cost in the project. Of this total, over one-third was for sand and clay ($53,432.00) and just under one-third ($39,369.70) was for a limerock base and the asphalt. Renting and operating a dozer was the next largest component at $27,097.00.

Progress on the earthwork and site sealing was hampered by rainfall, but all work was finally completed by November 1983. Grading took approximately 4 months and was done between the end of April and August 1983. Sodding involved 2 months between July 6 and September 15, 1983, and paving from mid-July to mid-October 1983. The majority of the work was done by five contractors, including: Jerry Blankenship Trucking, Big John's Excavating, Garner Asphalt Paving, Art's Sprinkler and Pumps, and Keene Brothers Trucking.

The cost of the surface collection system, including the pumping stations, was approximately $68,660. The major components of the above cost included $8,628 for an 8360 square foot lined retention basin with supplies, $8,462.52 for various equipment rental, $8,789.82 for parts and labor to wire the pumping stations, and $7,200 for four catch basins. Another $13,975.00 was spent to construct slag bins and ramps. The retention basin was installed in mid-August 1983, but had to be entirely rebuilt. After the pond was rebuilt, well points had to be installed to dewater the bottom so that the liner could be properly placed. It was considered finished by October 1983.

Both pumping stations were constructed, wired, and operable by February 1984 and the graywater reuse system, the last segment of the project, was finished so that the stormwater management program was fully operational by mid-May 1984. The estimated completion date was much before this, but long delivery time for pumps and equipment forced GCL to spend time treating stormwater rather than groundwater, causing additional delays and forcing construction to extend past the expected date.

TABLE 3. STORMWATER MANAGEMENT PROGRAM - GULF COAST LEAD COMPANY, TAMPA, FLORIDA

A. Impermeable Surface Seal	
Sand and clay	$ 53,432.00
Limerock base and asphalt	$ 39,369.70
Dozer rental and operation	$ 27,097.00
Topping	$ 8,351.00
Additional labor for installation of sod	$ 5,366.08
91,700 square feet of sod	$ 4,232.60
Sprinkler system for cap	$ 3,911.15
126 pallets of sod	$ 2,205.00
368 yards fill dirt	$ 1,485.75
Other costs	$ 595.00
Subtotal	$146,045.28
B. Surface Collection	
Pond liner and supplies	$ 8,629.06
Equipment rental (dewatering and miscellaneous)	$ 8,462.52
Catch basins (4)	$ 7,200.00
Flow meters and other equipment	$ 5,938.75
Supplies	$ 3,159.48
Outside consultants (Palco Lining Co. and Moretrench American)	$ 3,184.89
2 motors and other equipment	$ 2,560.82
Slag bins and ramp	$ 13,975.00
Subtotal	$ 53,110.52
C. Pumping Stations	
Parts and labor for wiring	$ 8,789.82
Construction	$ 6,937.80
Subtotal	$ 15,727.62
Total	$214,883.42

Source: Gulf Coast Lead 1984

Shallow Groundwater Withdrawal

Seven recovery wells at a total cost of $8,450 were installed in the battery case area by June 1983. Another 20 recovery wells were placed along the periphery in August for $7,000. All of the work was done by Mixon Foundation and Drilling Company. The manifold system connecting the well point pump ($9,240) with the treatment plant, finished in November 1983, cost approximately $10,000 and was installed by Moretrench American Company. Additional equipment, labor, and supplies came to $18,742.59, bringing the total cost of the system to over $44,000, as noted in Table 4. Delays in starting up the withdrawal system were due to a problem in locating personnel trained to operate it properly, but pumping finally was initiated in March 1984.

Wastewater Treatment Plant

As mentioned earlier, GCL had spent over $140,000 on its chemical treatment facility before implementing the remedial plan. Equipment purchased for the required upgrading in 1983 came to $10,590.90, as shown in Table 5. The cost of designing these modifications was not available because it had already been incorporated into the total for Environmental Engineering Consultants. This is true for the cost of designing the other remedial projects at Gulf Coast Lead.

Groundwater Monitoring Program

The total approximate cost for this program was $30,000. This is taking into account that the permanent and present program uses the monitoring wells installed in the preliminary monitoring program started up in 1981. At that time, the cost of installation was $16,210. Another $3,821 went towards independent chemical analyses during the one-year period 1980 to 1981. No figures were available for sampling and analysis for 1982 and part of 1983. It is estimated that the in-house analyses that the company plans to use for the current program will be $10,000 a year, assuming a cost of $30 per sample for quarterly collection and analysis.

Gulf Coast Lead hired a technician in February 1983, with the primary function of collecting samples and generating data for the system, but a separate cost for the technician's services was not available.

GCL's capital expenditures were close to $300,000 between January 1983 and February 1984, at which time it was estimated that remaining expenditures for the acid

TABLE 4. GROUNDWATER WITHDRAWAL - GULF COAST LEAD COMPANY, FLORIDA

A. Installation	
Phase I wells	$ 8,450.00
Phase II wells	$ 7,000.00
Subtotal	$15,450.00
B. Plumbing	
Manifold system, installation	$12,012.64
Well point pump and vacuum system	$ 9,240.00
Plastic pipes and fitting	$ 3,321.97
2 motors and butterfly valves	$ 1,326.39
2 diaphragm valves	$ 1,276.80
Other materials and supplies	$ 1,107.20
Masterflex pump drive and head	$ 457.59
Subtotal	$28,742.59
Total	$44,192.59

Source: Gulf Coast Lead 1984

TABLE 5. WASTEWATER TREATMENT PLANT - GULF COAST LEAD, COMPANY, TAMPA, FLORIDA

A. Construction (pre-remedial plan)	$140,716.67
B. Upgrading	
Converters, pH electrodes, and other equipment	$ 3,775.76
Duplex sump pump system	$ 3,145.00
Simplex sump pump system	$ 2,110.00
Lighting mixer	$ 854.70
Metering pump	$ 705.44
Subtotal	$ 10,590.90
Total	$151,307.57

Source: Gulf Coast Lead 1984

reaction barrier and for replacing a damaged monitoring well would not exceed another $50,000.

PERFORMANCE EVALUATION

The effectiveness of the remedial response technologies at the GCL site cannot be evaluated at this writing (3 months after installation and startup). However, the selection of these response technologies appears to have considered all viable alternatives, and the operation of the response equipment has proceeded as expected. Unless major problems arise, such as clogging of the extraction wells, improvements in the quality of the groundwater should be apparent within a 5-year period.

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LIPARI LANDFILL

PITMAN, NEW JERSEY

INTRODUCTION

NCP References

The Lipari property is a 16-acre (6.5-ha) site in a mixed agricultural and residential area in the southern tip of Mantua Township, adjacent to the towns of Pitman and Glassboro, in Gloucester County, New Jersey (Figure 1). Six to seven acres (2.4 to 2.8 ha) of the property were used for landfill purposes. Between 1958, when the site was purchased by Nicholas Lipari for use as a sand and gravel borrow pit, and 1971, when landfill operations stopped, sand and gravel were removed from trenches measuring 30 to 50 feet (9 to 15 m) in width and 50 to 85 feet (15 to 26 m) in length. After excavating the trenches to a depth of 6 to 15 feet (1.8 to 4.6 m), they were backfilled with industrial and domestic wastes, the total of which are estimated at 12,000 cubic yards (9,200 m^3) of solid wastes and 2.9 million gallons (11 million liters) of liquid wastes including solvents, paint thinners, formaldehyde, paints, phenol and amine wastes, dust collector residues, resins, and ester press cake.

Concern over the site has focused on the contamination of two nearby streams and the 26-acre (10.5-ha) Alcyon Lake, as well as two aquifers which once served locally as agricultural and residential drinking water sources. There has also been concern among local residents regarding chemical odors emanating from the site. Further, leachate seeps to surface water were first noted in the vicinity of Chestnut Branch, a tributary of Mantua Creek, by the New Jersey Department of Health officials in 1970. Since then there have been numerous studies on the nature and extent of the pollution, examining air, soil, sediments, fish tissue, and both surface- and groundwater samples. Chemical analyses of the leachate demonstrated the presence of 25 priority pollutants, among other organic and metal wastes. Detected in the leachate were substantial quantities of the suspected carcinogen bis (2-chloroethyl) ether (130 mg/l), phenol (4.4 mg/l), ethylbenzene (1.1 mg/l), benzene

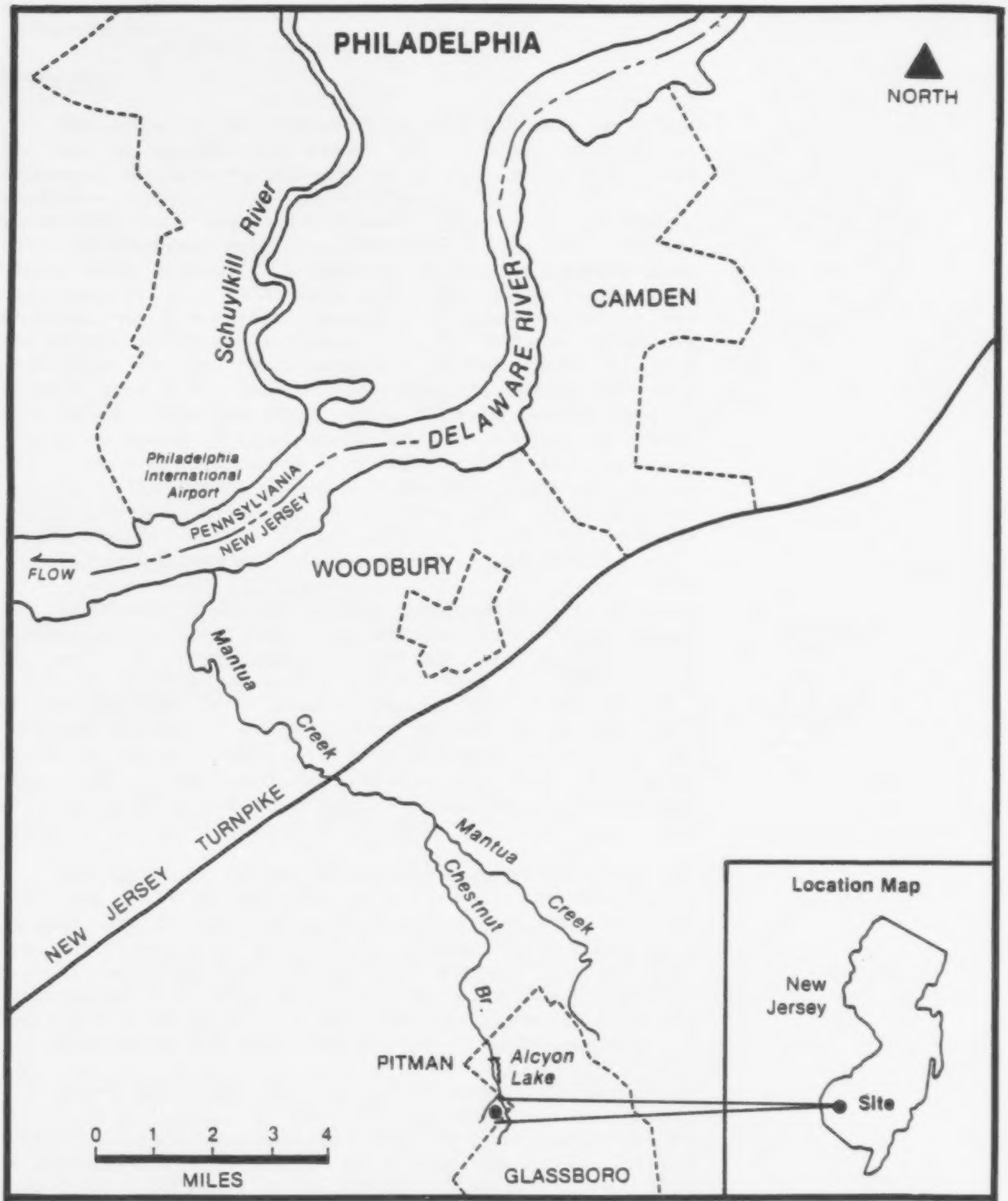


Figure 1. Regional Location Map, Lipari Landfill, Gloucester County, NJ

Source: Radian 1983a

(2.0 mg/1), and toluene (22.4 mg/1). Analyses of samples of groundwater and surface water revealed similar contamination.

Background

The property was purchased in 1958 by Nicholas Lipari for use as a sand and gravel pit. After excavation, trenches, produced by the removal of sand and gravel, were used for landfilling activities. The trenches were backfilled with household wastes, liquid and semi-solid chemical wastes, and other industrial wastes. Liquid wastes were emptied from containers and bulk-dumped into the landfill from 1958 until 1969, and solid wastes were disposed until May 1971, when the site was closed by the New Jersey Solid Waste Authority. In 1969, at least one explosion and two fires occurred at the landfill, when barrels were being emptied and when the wastes and soil were being compacted (CMA 1980). Liquid wastes were no longer accepted for disposal at the site after these events because of concern over related fire and explosion hazards. The amount of waste materials deposited in the landfill is uncertain, but they are estimated at 12,000 cubic yards (9,200 m^3) of solid wastes and 2.9 million gallons (11 million 1) of liquid wastes.

Leachate from the wastes percolated through the predominantly sandy vadose zone down into the Cohansey Aquifer. It also migrated into the surface waters of nearby tributaries of Mantua Creek. Chemical constituents of the leachate have been found in Rabbit Run and the Chestnut Branch of Mantua Creek, as well as Alcyon Lake, which is about 1,000 feet (305 m) downstream from the site. Mr. Lipari and New Jersey Department of Health personnel observed leachate seeping from the ground surfaces beside the landfill in 1970.

The site was frequented by children of the area and was used as a motorcross bike trail. Naturalists, joggers, and hikers also used the site from time to time. Others potentially exposed to the pollution included persons employed to maintain and harvest the orchards surrounding the site. Eighteen houses are located within 250 yards (230 m) of the site boundary, and four houses are as close as 100 yards (91 m) from leachate seeps.

Under administrative and court orders to cease and desist from polluting the Chestnut Branch, Mr. Lipari attempted to mitigate the leachate flow and noxious odors by diverting surface runoff and liming the site. Further inspection of the site by State personnel showed that these activities were unsuccessful in abating the problem.

Synopsis of Site Response

A removal action at the site was initiated in July 1982 by the Emergency Response and Hazardous Materials Inspection Branch of the U.S. Environmental Protection Agency, Region II. The removal action consisted of the installment of 3,438 linear feet (1,048 m) of 8-foot (2.4-m) high chain-link fence to limit access to the landfill. Subsequently, remedial construction activities began on August 30, 1983, with the installation of a 360° slurry wall surrounding 16.7 acres (6.8 ha) of the site. The cut-off wall was constructed under the supervision of the U.S. Army Corps of Engineers (ACE). The wall was designed to segregate the bulk of the contaminants in the landfill from the surrounding aquifer through the use of a low-permeability soil-bentonite backfill, keyed into an underlying aquitard. In addition, a synthetic cap of high-density polyethylene (HDPE) was emplaced over the site to prevent the infiltration of precipitation and surface waters. A passive, gas-venting system underlies the cap, with surface vents sealed in HDPE boots. A surface water drainage system also overlies the cap to direct the collection of rainwater on the surface. A well monitoring system utilizing previously drilled and new wells is currently being implemented under the direction of the U.S. EPA. Off-site impacts and remedial actions are also being evaluated. Options for long-term groundwater pumping, pretreatment, and treatment at a local Publicly Owned Treatment Works (POTW) are currently being considered by the U.S. EPA. Short-term groundwater extraction using a wellpoint system was necessary to lower the groundwater level enough to finish construction on the cap. Groundwater pumped in the short-term underwent pretreatment, consisting of sand filtration and activated carbon treatment, before being discharged to the local POTW.

SITE DESCRIPTION

The Lipari Landfill is located at latitude 39°43'10" and longitude 75°08'37" at the southwestern edge of the town of Pitman. The landfill is approximately 1500 feet (457 m) north of U.S. Route 322 and 1.5 miles (2.4 km) west of Glassboro State College. Bordering the site are two small streams, Chestnut Branch and Rabbit Run, which enter Alycon Lake 1000 feet (305 m) downstream of the site. In proximity to the northeast portion of the site, there is a housing development containing single family homes. Surrounding much of the site are fruit orchards (Figure 2).

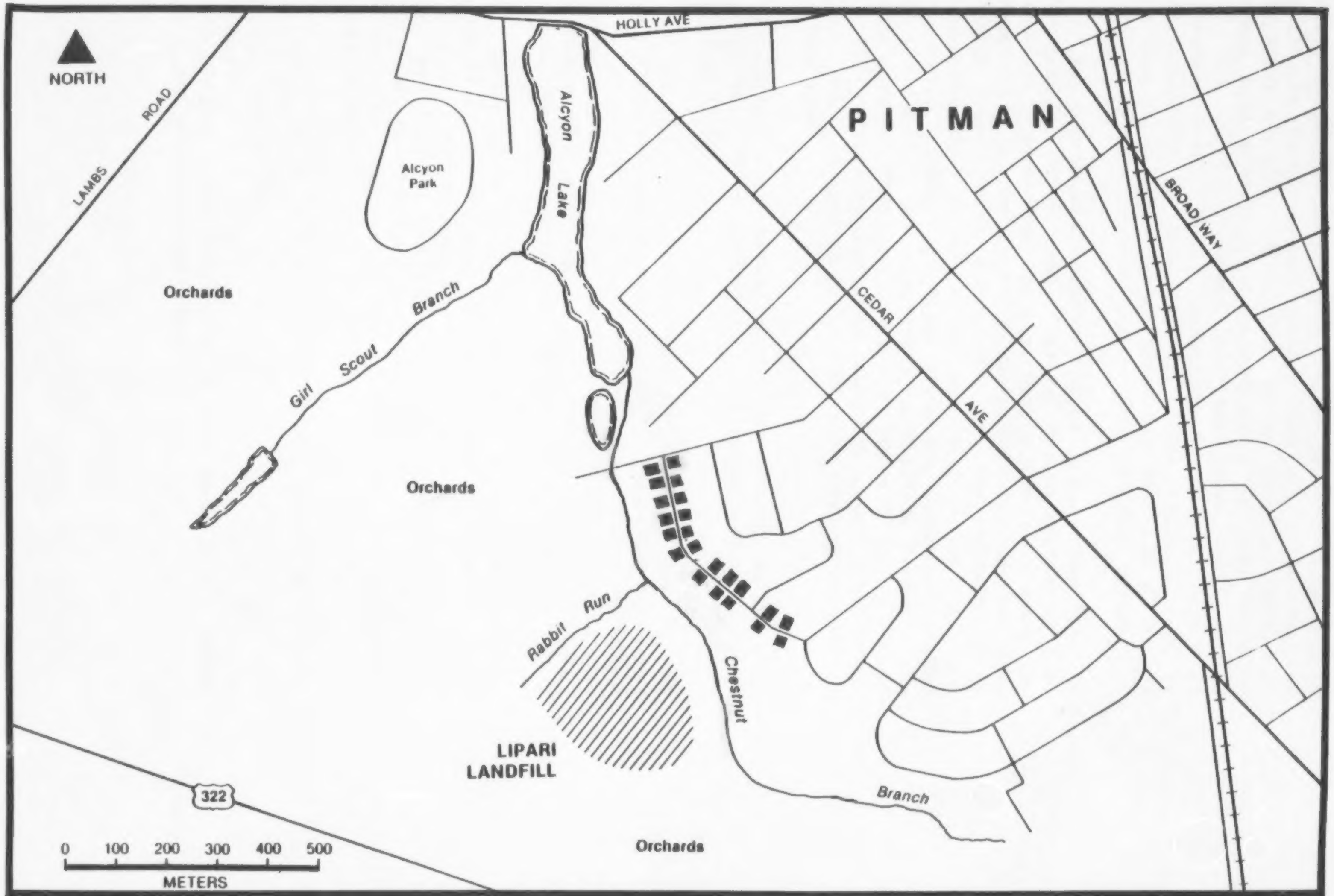


Figure 2. Site Location Map, Lipari Landfill, Gloucester County, NJ

Source: Radian 1983a

Surface Characteristics

The Lipari Landfill lies within the Atlantic Coastal Plain physiographic province. Site-specific topography is generally low-lying and gently rolling, reflecting the regional terrain. Elevations in the immediate site area range from a maximum of approximately 140 feet to about 85 feet (43-26 m) above mean sea level (msl) in the Chestnut Branch Valley, resulting in a local relief of approximately 55 feet (17 m). The landfill site is located at an elevation of about 125 feet (38 m) atop a 30-foot (9-m) escarpment that borders Chestnut Branch.

As previously mentioned, the Lipari Landfill is bordered by two streams, Chestnut Branch and Rabbit Run. Chestnut Branch flows in a northerly direction along the east side of the landfill and eventually empties into Mantua Creek, which discharges into the Delaware River approximately 9 miles (15 km) northwest of the site (see Figure 1). Rabbit Run flows along the northwestern edge of the landfill and discharges to Chestnut Branch. The two streams, draining an area of about 3 square miles (8 km^2), converge and flow north to empty into Alcyon Lake, which is located about 1000 feet (305 m) downstream of the site.

Stream flow measurements were taken on several occasions. These measurements are summarized in Figure 3 (Radian 1982a).

The natural soils in the site area belong to the Aura-Sassafras-Downer Association. They are primarily Aura Series (ArB, AsC, and AuC_3) and secondarily Downer Series (DOB) soils. Because the landfill area was excavated for sand and gravel and subsequently filled, natural soils are absent on the western side of the site.

Other minor soils at the site include Fallsington loam (Fa) at the head of Rabbit Run; Westphalia soils (Whc) in a narrow band north of, and parallel to, Rabbit Run; and Alluvial deposits (Ad), along the Rabbit Run and Chestnut Branch valleys (Radian 1982a). Figure 4 illustrates the distribution of soil types at the Lipari Landfill site.

Aura soils have a grayish-brown, coarse to medium, sandy loam surface layer. The deeper layers begin at depths between 18 and 36 inches (45-91 cm) and are composed of a reddish clay. Aura soils are extremely hard when dry and often firm to very firm when moist. These soils are moderately permeable.

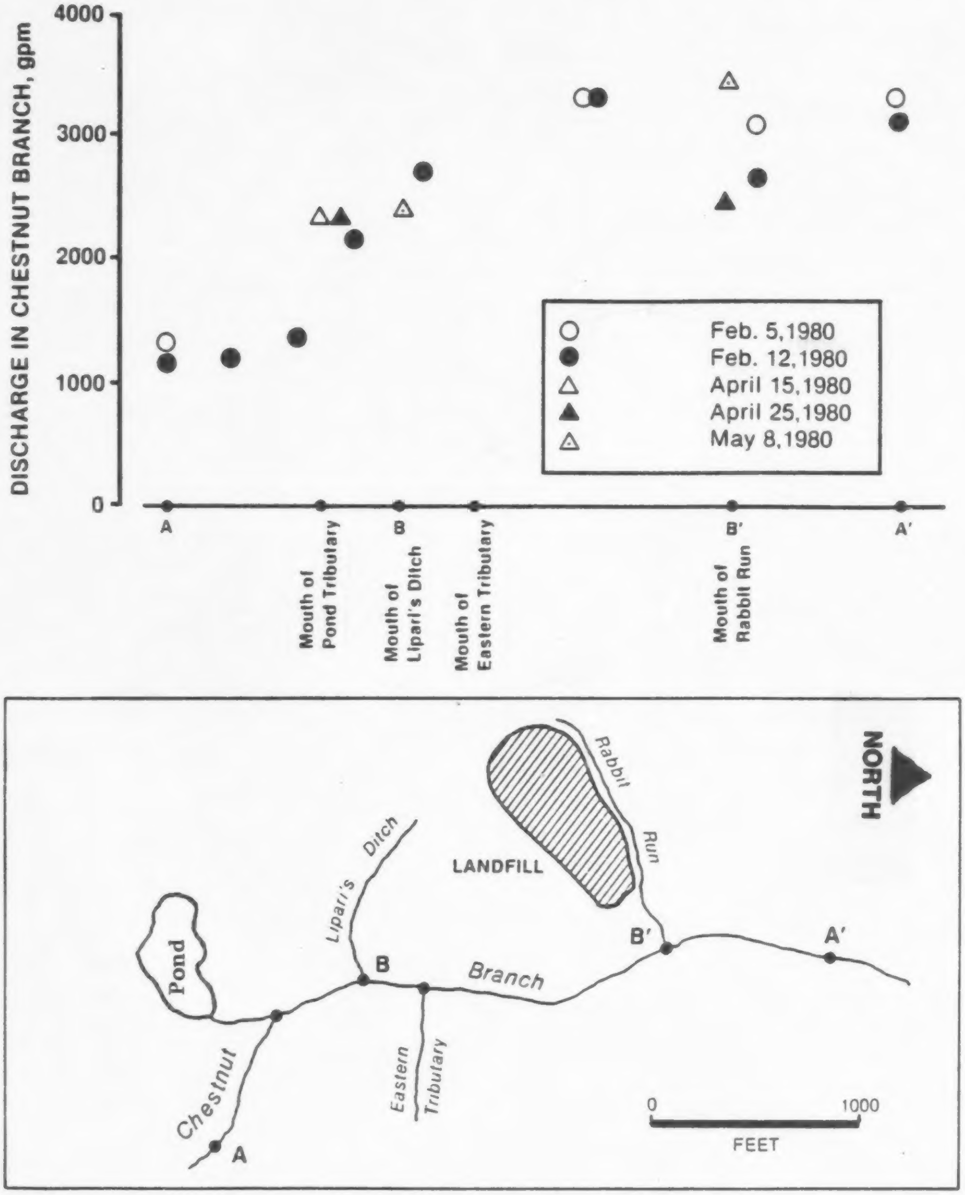


Figure 3. Surface Water Flow Measurements On Chestnut Branch

Source: Radian 1982a

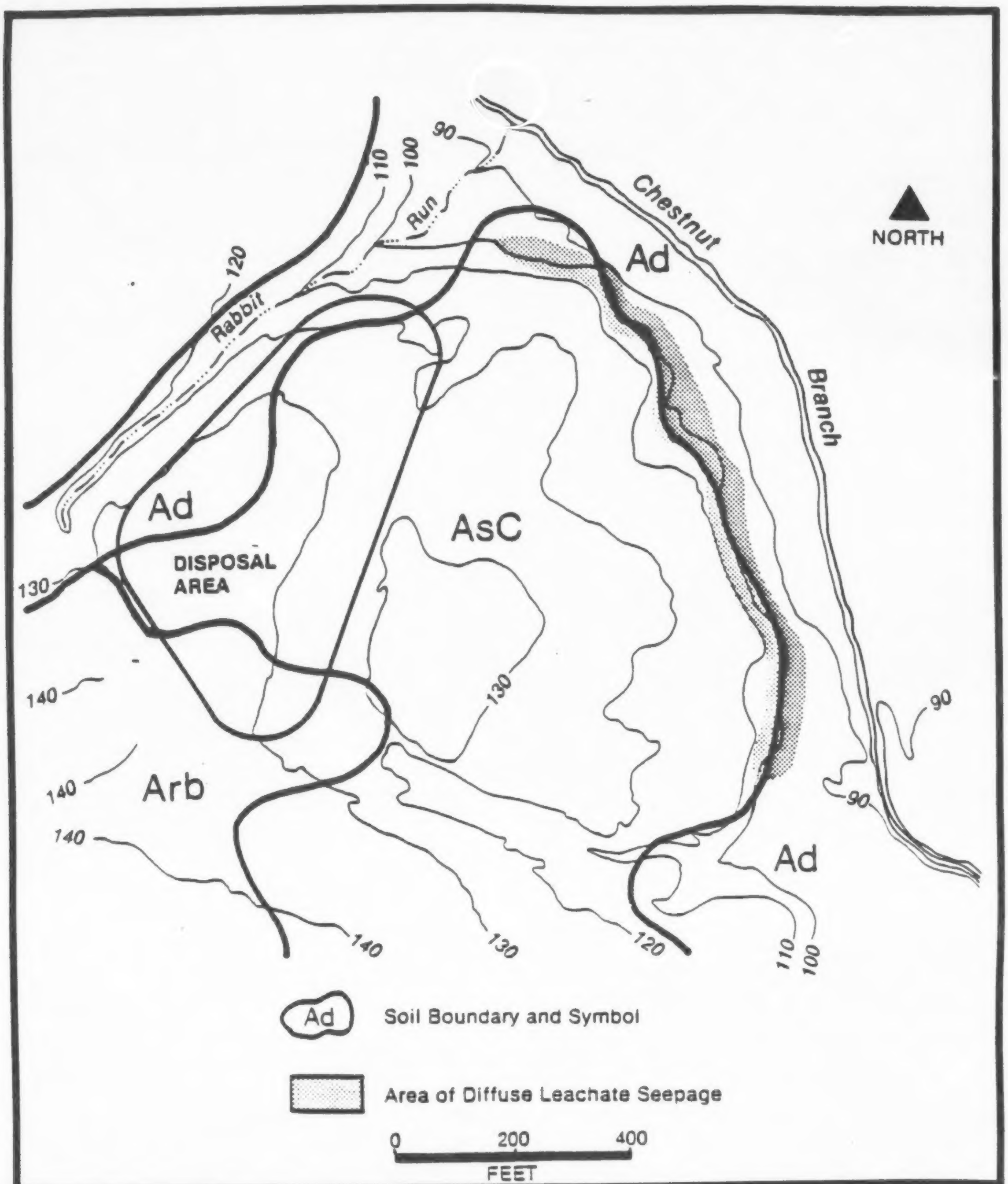


Figure 4. Distribution of Soil Types at the Lipari Landfill Site, NJ (see text for soil type descriptions)

Source: Radian 1982a

Downer soils, most commonly found along the Delaware River and in the eastern part of the county, consist of a grayish-brown plow layer over yellowish-brown light sandy loam subsoil. The loam subsoil is underlain by sand or gravelly sand. The average thickness of the subsoil is 14 inches (36 cm), but ranges from 10 to 25 inches (25-64 cm). These soils are nearly level to gently sloping and are well drained.

The local climate is classified as humid continental. Most of the weather systems that affect the site either develop in the Midwest and are steered eastward by the prevailing westerly winds aloft, or move northeastward parallel to the Atlantic Coast. The average annual temperature is 52°F (-3°C). Average daily winter temperatures range between 25°F and 42°F (-18°C and -19°C), with an average low of about 10°F (-26°C). Average daily summer temperatures range between 82°F and 86°F (14°C and 16°C) with highs in the upper nineties. Cloud cover is at a minimum during the summer months. Cloudiness is more prevalent in winter than in other seasons because cold fronts and coastal low-pressure systems are more frequent.

300.68(e)(2)(i)
(E)
climate

Prevailing winds during winter are from the west-northwest and average 11 miles per hour (17 km/hr). During summer months, prevailing winds are from the south-southwest and average 8 miles per hour (13 km/hr).

Precipitation averages 41 inches (104 cm) per year. Snowstorms seldom exceed 10 inches (25 cm), although a few snowfalls of 20 inches (51 cm) or more have occurred. Thunderstorms occur in all seasons. Heavy rains can deluge the region with as much as 3 to 6 inches (8 to 15 cm) in a 24- to 48-hour period, respectively.

The Lipari Landfill is situated in the middle of Gloucester County, immediately southwest of the urban community of Pitman and east-northeast of a predominantly rural area of the county. The immediate land use in the area surrounding the site is mixed urban/agricultural. The urbanized communities of Pitman and Glassboro are both located within one mile of the site.

300.68(e)(2)(i)
(A)
population at
risk

To the northwest and southwest of the site, land is used predominantly for apple and peach orchards. In addition, about five houses exist on these sides of the landfill along U.S. Highway 322.

Hydrogeology

The Lipari Landfill is underlain by unconsolidated to poorly consolidated fluvial and marine deposits of

Cretaceous and Tertiary age. The surficial geologic material is of Upper Miocene age and belongs to the Cohansey Sand Formation. Underlying this formation are the silty and clayey sands of Middle Miocene age known as the Kirkwood Formation. Separating the two sand units and serving as the top member of the Kirkwood Formation is a dense silty clay zone referred to as the Kirkwood Clay. The Kirkwood Formation is underlain by the Manasquan Formation of Eocene age which also generally consists of layers of clay, silt, and fine to coarse sand. The Vincentown Formation of Paleocene age directly underlies the Manasquan Formation and consists of limey sandstone. Older geologic units that underlie the Vincentown Formation include Cretaceous aged materials such as the Hornerstown-Navesink Sands, the Mount Laurel-Wenonah Sands, and the Magothy-Raritan Aquifer.

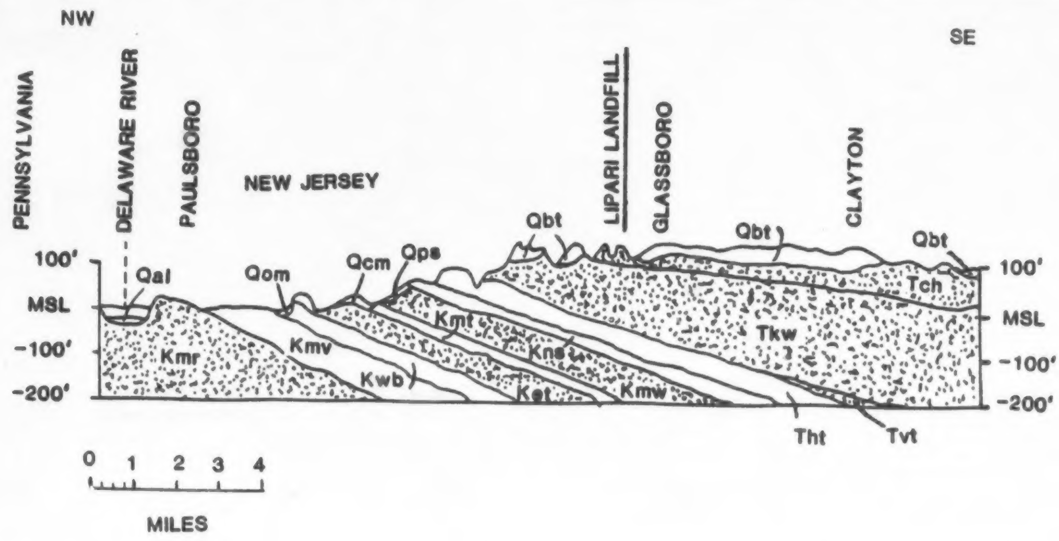
300.68(e)(2)(i)
(D)
hydrogeological
factors

Cohansey Sand Formation--

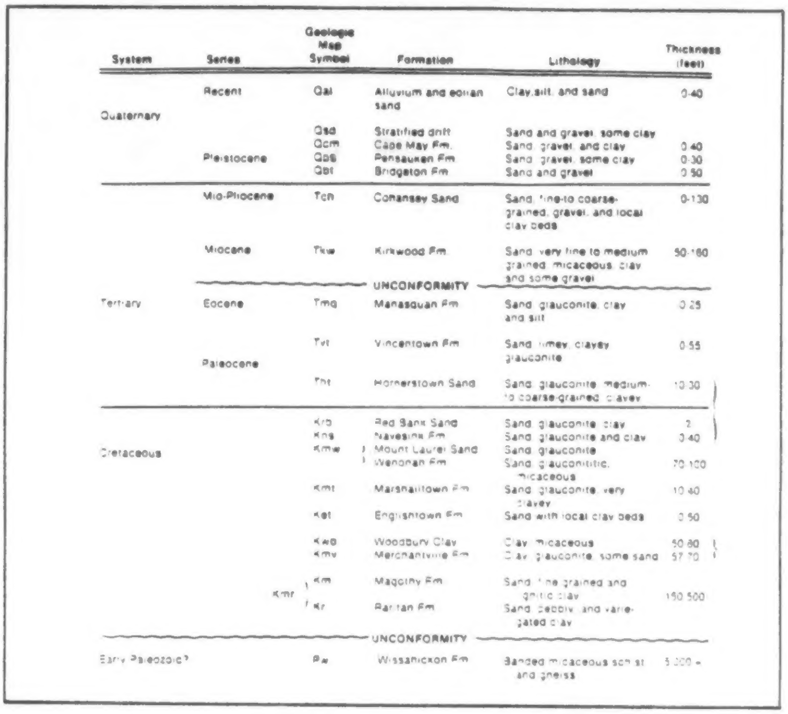
The Lipari Landfill originated as a borrow pit where sand and gravel were excavated from the Cohansey Sand. The present boundaries of the waste disposal pit and adjacent contaminated areas are situated in the Cohansey Sand Formation (Figure 5). The sand unit generally consists of fine to medium sand with lenses of clay and gravel. This material is usually fairly loose and unconsolidated but some weak consolidation does occur because of iron concentration. Within the study area the Cohansey Sands range in thickness from 16.5 feet to 55.0 feet (5 to 17 m) (JRB 1983a).

Based on sampling conducted during various drilling programs at the site, the Cohansey Sand has been differentiated into two zones, the Upper and Lower Cohansey Sand. The Upper Cohansey Sand is composed of fine to coarse sand, and is poorly sorted with sections containing varying amounts of gravel. There are also relatively well sorted stringers of fine sand randomly distributed throughout this interval (JRB 1983a). This upper zone generally occurs above an elevation of 100 feet (30 m) msl and extends downward to between 6 inches (15 cm) and 7 feet (2 m) above the Kirkwood Clay (REWAI 1981a, JRB 1983a).

The Lower Cohansey Sand consists of greenish-gray, fine to medium sand with some silt and no gravel. This zone lies between the coarser sand and gravel above and the dense Kirkwood clay layer below. The top of this lower sand zone occurs at an elevation of about 100 feet (30 m) and ranges in thickness from 6 inches (15 cm) to 7 feet (2 m) within the study area (JRB 1983a). Because of the nearly horizontal plane of the top of the unit, and



STRATIGRAPHY OF GLOUCESTER COUNTY



System	Series	Geologic Map Symbol	Formation	Lithology	Thickness (feet)
Quaternary	Recent	Qal	Alluvium and eolian sand	Clay, silt, and sand	0-40
		Qsd	Stratified drift	Sand and gravel, some clay	
		Qcm	Cape May Fm.	Sand, gravel, and clay	0-40
	Pleistocene	Qps	Pensauken Fm	Sand, gravel, some clay	0-30
		Qbt	Bridgeton Fm	Sand and gravel	0-50
Tertiary	Mio-Pliocene	Tch	Cohansey Sand	Sand, fine-to coarse-grained, gravel, and local clay beds	0-130
	Miocene	Tkw	Kirkwood Fm	Sand, very fine to medium grained, micaceous, clay and some gravel	50-180
			UNCONFORMITY		
	Eocene	Tmq	Manasquan Fm	Sand, glauconite, clay and silt	0-25
		Tvt	Vincentown Fm	Sand, limey, clayey glauconite	0-55
	Paleocene	Tht	Hornerstown Sand	Sand, glauconite, medium- to coarse-grained, clayey	10-30
Cretaceous		Krb	Red Bank Sand	Sand, glauconite, clay	2
		Kns	Navesink Fm	Sand, glauconite and clay	0-40
		Kmw	Mount Laurel Sand	Sand, glauconite	
			Wenonah Fm	Sand, glauconitic, micaceous	70-100
		Kmt	Marshalltown Fm	Sand, glauconite, very clayey	10-40
		Ket	Englishtown Fm	Sand with local clay beds	0-50
		Kwb	Woodbury Clay	Clay, micaceous	50-80
		Kmv	Merchantville Fm	Clay, glauconite, some sand	57-70
	Kmr	Km	Magothy Fm	Sand, fine grained and lignitic clay	150-500
		Kr	Raritan Fm	Sand, pebbly, and variegated clay	
			UNCONFORMITY		
Early Paleozoic?		Pw	Wissahickon Fm	Banded micaceous schist and gneiss	5,000 +

Figure 5. Generalized Geologic Cross Section Through Gloucester County, NJ

Source: REWAI 1980

the southeasterly dip of the underlying strata, the Lower Cohansey Sand thickens toward the southeastern corner of the site (REWAI 1981a).

Groundwater is recharged to the Cohansey by direct infiltration of rain through outcrop areas. In the Pitman area, the Cohansey has historically been used for farm and domestic water supplies. Despite the large quantitative potential for its further development, Cohansey groundwater has been rendered undesirable for domestic use because of the naturally high iron concentrations (REWAI 1980).

Kirkwood Formation--

The Kirkwood Formation underlies the Cohansey sands and generally consists of dark greenish-gray, very fine to medium sand, with a little silt, traces of mica, and traces of fossilized shell fragments. This formation is about 75 feet (23 m) thick beneath the site (REWAI 1981a). At the top of the unit at the site, however, is a distinctive zone of silt and clay, referred to here as the Kirkwood Clay, which effectively separates the main body of the Kirkwood Formation from the Lower Cohansey Sand. The clay's thickness in the immediate site area ranges between 9.0 and 16.8 feet (3 and 5 m). The Kirkwood Clay zone, like the Kirkwood Sand, generally dips to the southeast and ranges in elevation from 92 feet to about 80 feet (28 to 24 m).

The recharge of groundwater to the Kirkwood Formation occurs through the direct infiltration of rain at its outcrops and through the downward seepage of water from the Cohansey Sand. The Kirkwood Sand is a minor aquifer in Gloucester County because of its relatively low permeability and insignificant water yield. Wells are not known to be completed in the Kirkwood near Pitman, NJ (REWAI 1980).

Older Geologic Units---

The Manasquan Formation underlies the Kirkwood Formation and generally consists of layers of clay, silt, and fine to coarse sand. This material, like the Kirkwood, is not generally permeable enough to yield significant amounts of groundwater, nor to allow high rates of natural groundwater flow through them. For these reasons, the Manasquan unit is a minor aquifer in the county. Wells are not known to be completed in the Manasquan Sands near Pitman (REWAI 1980).

The Vincentown Formation is composed of light bluish-green fine to coarse sand which is variably lithified with clay and calcite cement. The unit is 18 feet (6 m) thick beneath the site and is an aquifer used as a groundwater resource in the area (REWAI 1981a).

The older geologic units which occur beneath the Vincentown Formation, such as the Hornerstown-Navesink Sands, the Mount Laurel-Wenonah Sands and the Magothy-Raritan Formations, are generally recharged by vertical leakage from overlying units. However, they are each separated from the overlying and underlying units by clay-rich aquitards and have not been threatened by the Lipari landfill problem (REWAI 1980).

Groundwater flow within the Cohansey Formation is controlled by the composition of the underlying strata, the structural dip of the strata, and surface topography. Because of the relatively impermeable Kirkwood Clay, the dominant flow direction of groundwater through the Cohansey Sands is horizontal rather than vertical. Based on the topographic setting of the landfill and the unconfined water table conditions which occur in the Cohansey sediments, groundwater flow is inferred to follow the overall surface drainage pattern which is generally easterly through the site, toward Chestnut Branch (REWAI 1980). Groundwater levels in the site area are between 10 and 15 feet (3 and 5 m) below the ground surface (REWAI 1981a).

Well-drilling efforts at the site have indicated that the top of the Kirkwood Clay gently dips (< 1.0%) to the southeast with noticeable rolls and undulations creating minor directional changes. In the absence of surface water erosion along the northern and northeastern boundaries of the site, which has created locations for groundwater discharge, overall groundwater flow would probably follow the dip of the Kirkwood Clay to the southeast. However, Chestnut Branch and Rabbit Run have truncated the Cohansey aquifer along the site's northern boundaries and have created a continuous seep line or discharge area to the northeast through which groundwater is able to flow. Further evidence of a northeasterly groundwater flow within the Cohansey Sands is the decrease in water level readings showing a decrease in head from the southwest to the northeast across the site (JRB 1983a).

These observations and evidence indicate that topography has a greater influence on groundwater flow direction and head levels than does the mild structural dip of the clay surface (JRB 1983a).

The average hydraulic conductivities of the Upper and Lower Cohansey sand units are reported to be 217 gpd (1.0×10^{-2} cm/sec) and 6.8 gpd/ft^2 (3.2×10^{-4} cm/sec), respectively. Based on these hydraulic conductivities (the flow of groundwater through each unit), the discharge rate of groundwater into the Chestnut Branch marsh from the Cohansey Sands was estimated to be a total of 40,800 gpd (1.8 l/sec) (REWAI 1981a).

Groundwater flow within the Kirkwood Formation in the study area is also in a northeasterly direction as indicated by groundwater level measurements. The head differential across the clay, between the Cohansey and Kirkwood Sands, ranges from 0 to 24 feet (REWAI 1981a). This indicates that groundwater does flow, to some minor degree, down through the clay in response to this head differential. However, as previously discussed, the low hydraulic conductivities of the clay restricts downward flow and the quantity of water that passes through to the lower Kirkwood Sand is extremely small. The hydraulic conductivity of the Kirkwood Clay underlying the site is about 3.2×10^{-9} feet per second (1×10^{-7} cm/sec) (REWAI 1981a).

The head differential between the Kirkwood and the Vincentown Formations suggests that both these units are also locally drained by the Chestnut Branch drainage system. The head differential indicates, however, that groundwater is flowing upward from the Vincetown to the Kirkwood. Contrary to the regional trend of lower units being recharged by downward leakage from the upper units, this indicates that the Chestnut Branch drainage system exerts local control over the groundwater flow in the Vincentown. The upward flow provides some evidence that pollutants are not entering the Vincentown Formation. Hydraulic conductivities for the Vincentown Formation in the vicinity of the site are unavailable.

WASTE DISPOSAL HISTORY

The Lipari Landfill was operated as both a sand and gravel excavation pit and a landfill for liquid, semi-solid, and solid household and industrial wastes from 1958 until May of 1971. Acceptance of liquid wastes for disposal ceased in December 1969 after two fires and at least one explosion occurred in connection with the dumping and compaction of the liquid wastes.

The general method of disposal was to excavate a trough measuring roughly 50 to 85 feet (15 to 26 m) long, 30 to 50 feet (1 to 15 m) wide and 6 to 15 feet (1.8 to 4.6 m) deep. Liquid and solid wastes were mixed and poured into the trough, and the containers used for transport of the liquid wastes were recycled, except in cases where the containers were not salvageable. After a layer of liquid and solid wastes was deposited in the trough, the wastes were compacted against the floor and sides of the trough with heavy machinery, and then covered with 10 inches (25 cm) of compacted earth fill. These steps were then repeated until the trough was filled, after which the trough was capped with 2 feet (.61 m) of compacted earth fill.

Although the exact amount of material discarded at the Lipari Landfill is unknown because detailed records were not kept, estimates of the wastes are generally around 2.9 million gallons (11 million l) of liquids and 12,000 cubic yards (9,200 m^3) of solids. Some of the known wastes which have been disposed in the landfill include paint thinners, paints, waste solvents, phenol and amine wastes, formaldehyde, and benzene. In addition, there has been one report that three barrels of explosive materials were also buried in the landfill (CMA 1980).

Chemical analyses of the leachate have quantified the amounts of a number of priority pollutants, including:

Phenol (4.4 mg/l)
Dichloroethane (5.8 mg/l)
Bis (2-chloroethyl) ether (210 mg/l)
Toluene (22.4 mg/l)
Dichlorobenzene (70 ug/l)
Trichloroethylene (<10 ug/l)
Cadmium (53 ug/l)
Arsenic (12.8 ug/l)
Chromium (130 ug/l)
Mercury (2.9 ug/l)
Lead (140 ug/l)
Copper (130 ug/l)

(Concentrations given are from various sampling efforts and represent orders-of-magnitude of contaminants). These and other organic compounds and priority pollutants were found in concentrations high enough to warrant the placement of this site as No. 5 on the first National Priorities List of hazardous waste sites, No. 1 on the updated list, and No. 1 in the state listing of New Jersey hazardous waste sites.

DESCRIPTION OF CONTAMINATION

The first signs of a potential problem at the Lipari Landfill were observed in 1970 by Mr. Lipari and New Jersey Department of Health personnel. During a routine inspection of the site, leachate was observed discharging from the side of the valley along Chestnut Branch. Following this observation, during the early and mid-1970s, only minor investigations were conducted at the site. It wasn't until the late 1970s that a comprehensive field investigation was initiated to determine the extent and degree of contamination at the Lipari Landfill and surrounding areas.

In summary, 25 priority pollutants, listed in Table 1, have been identified in either leachate samples taken from the Lipari Landfill, water samples taken from Rabbit Run, Chestnut Branch and Alcyon Lake, or groundwater samples collected from on-site monitoring wells (Radian 1982a, REWAI 1981a). In a large number of samples, levels of these compounds exceeded limits of water quality criteria defined by EPA in the Clean Water Act.

This section summarizes the findings of those investigations that most strongly influenced the final remedial actions implemented at the site.

Subsurface conditions at the landfill were initially investigated during the summer of 1979 when four on-site test borings were drilled at the direction of Gloucester County. Three of the four shallow (20 ft; 6 m) monitoring wells installed at the boring locations within the landfill showed contamination in the water table aquifer (Cohansey Sands) (CMA 1980). The groundwater discharging into Chestnut Branch through the seeps along the north-northeastern boundary of the landfill was also found to be contaminated (CMA 1980).

300.63(a)(2)
investigation

As part of a hydrogeological study conducted in 1979, an electrical earth-resistivity survey was performed which indicated that groundwater of extremely low resistivity was apparent on both sides of Chestnut Branch near the northern toe of the landfill. This suggested that contaminated groundwater originating in the landfill existed in the subsurface between the landfill and the stream (CMA 1980).

300.64(a)
preliminary
assessment

300.68(e)(ii)
extent of present or expected migration

During autumn of 1979, EPA Region II conducted analyses of water samples taken from shallow (20 to 25 ft; 6 to 8 m) and deep (130 to 150 ft; 40 to 46 m) domestic wells closest to the landfill. These wells were not affected by the leachate. Preliminary analysis for bis (2-chloroethyl) ether (BCEE) on a composite sample from these wells did not show concentrations at the detection limit of 4 ppb (ug/l) (CMA 1980).

Between the summer of 1979 and spring of 1980, two major surface water sampling efforts were undertaken at the Lipari Landfill. EPA Region II, in August 1979, collected surface water samples from four major leachate seeps along the northeast side of the landfill, Rabbit Run, Chestnut Branch, and Alcyon Lake (Figure 6). The most comprehensive set of data generated during this

TABLE 1. LIST OF PRIORITY POLLUTANTS IDENTIFIED AT THE LIPARI LANDFILL

- Acrolein
- Acrylonitrile (skin)[a]
- Arsenic[a]
- Benzene[b]
- Beryllium[b]
- Bis (2-chloroethyl) ether
- Bis (2-chloroisopropyl) ether
- Cadmium (dust)
- Cadmium (fume)
- Chlorobenzene
- Chloroform[b]
- 2-Chlorophenol
- Chromium (soluble chromic, chromous salts as Cr)
- Chromium (certain soluble and insoluble Cr VI comounds)[a]
- Chromium metal and insoluble salts
- 1,1-Dichloroethane
- 1,2-Dichloroethane
- 1,1-Dichloroethylene
- Ethyl benzene
- Lead
- Mercury, inorganic
- Mercury, alkyl (skin)
- Methyl chloride
- Methylene chloride
- Nickel, metal & soluble compounds
- Phenol (skin)
- Toluene (skin)
- Trichloroethylene
- Vinyl chloride[a]

[a] Known human carcinogen.

[b] Suspected human carcinogen (ACGIH 1981).

Source: Radian 1982a

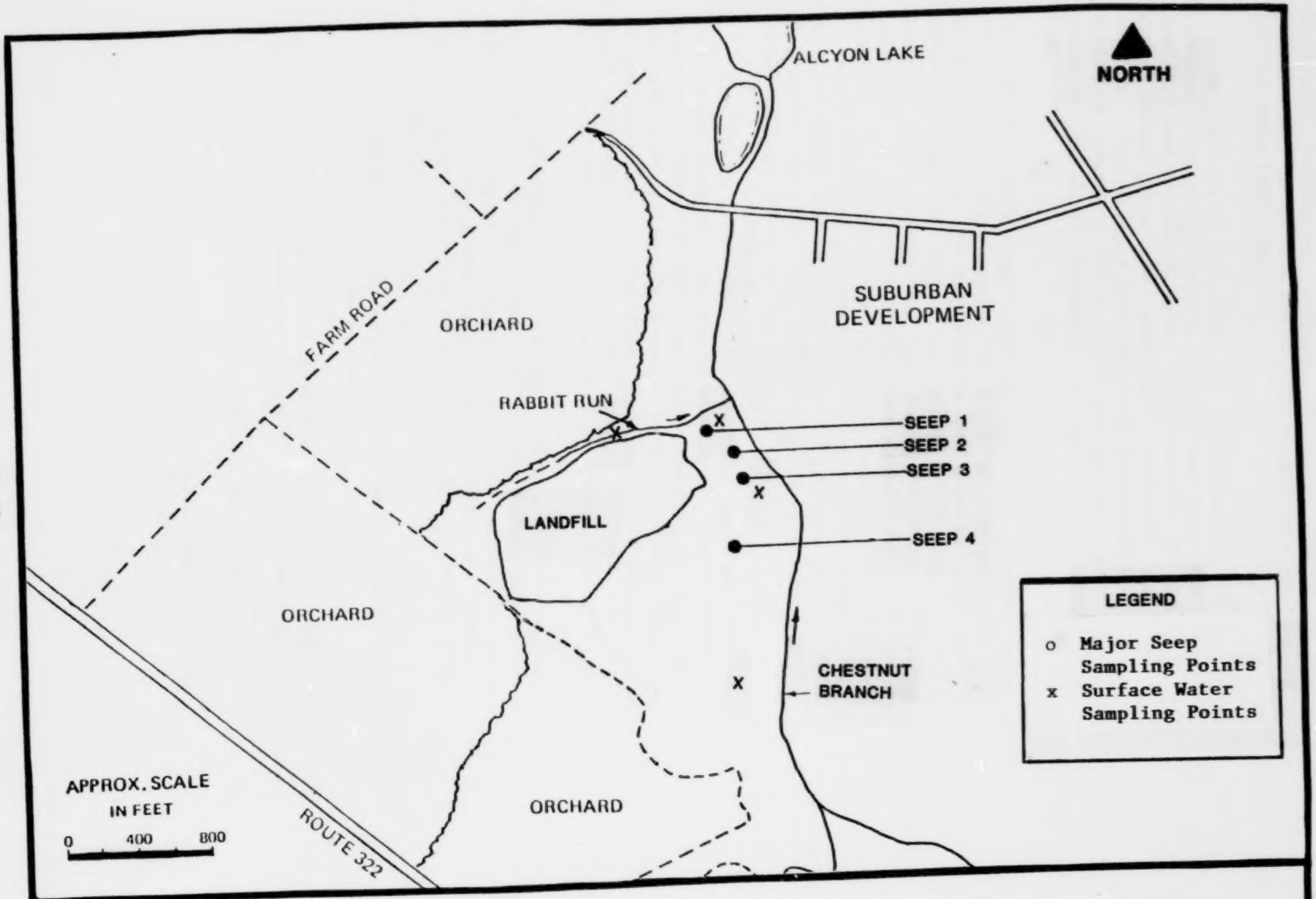


Figure 6. Map of Lipari Landfill Area Showing EPA Sampling Points

Source: CMA 1980

effort was from samples collected on August 22, 1979. Twelve samples were collected and analyzed for all National Resources Defense Council (NRDC) toxic pollutants. Table 2 presents the significant portion of the raw data (CMA 1980).

In the spring of 1980, an investigation of uncontrolled chemical leachate discharges from the Lipari Landfill was conducted under the direction of EPA. The study investigated the leachate's character and treatability. The primary goal of this investigation was to delineate measures which would economically provide the greatest degree of abatement in the shortest amount of time.

In May 1980, two sets of leachate samples were collected and characterized in terms of conventional and priority organic and heavy-metal pollutants. The locations of sampling points are shown on Figure 6. All samples were composited and then analyzed with the exception of those collected from Rabbit Run. Because leachate discharged to Rabbit Run is significantly diluted by uncontaminated groundwater, samples from Rabbit Run were collected and analyzed separately (REWAI 1980). The analyses' results for the three samples that were composited are shown in Tables 3, 4, and 5.

In general, the May 1980 leachate sampling did not provide new insight into the nature of the Lipari Landfill leachate. The leachate character appeared to vary over time and from station to station, with pollutants observed at one time and undetectable at others. In conclusion, there were no significant differences between the 1980 results and those of previous studies (REWAI 1980).

In September 1981, another investigation was completed at the Lipari Landfill. This investigation was primarily designed to facilitate the construction of a cutoff wall around the zone of contaminated groundwater. The 1981 study was designed to provide the following types of information:

(1) Stratigraphic information to better define flow of contaminated groundwater

(2) Quantification of downward leakage of contaminated groundwater through the Kirkwood Clay

(3) Refined estimates of leachate discharge rates

(4) Degree and distribution of contaminant levels in groundwater and the Chestnut Branch marsh.

TABLE 2. EPA DATA ON NRDC PRIORITY POLLUTANT ANALYSIS OF SAMPLES TAKEN AUGUST 22, 1979 (ug/l)

	LiPari Landfill Leachate				Rabbit Run		Chestnut Branch		Alcyon Lake			
Compound	#1	#2	#3	#4	Upstream/Downstream		Upstream/Downstream		Inflow	Composite	W. Outflow	E. Outflow
Benzene	1,456.	2,012.	1,620.	171.	ND	46.	ND	ND	ND	ND	ND	ND
Bis (2-Chloroethyl/Ether)	ND	130,000.	210,000.	54,000.	2,300.	13,000.	ND	890.	780.	240.	270.	330.
Cadmium	3.	53.	9.	6.	8.	4.	3.	3.	3.	3.	3.	3.
Chromium	40.	130.	30.	50.	10.	10.	10.	10.	10.	10.	10.	10.
Copper	110.	130.	110.	95.	23.	23.	14.	13.	13.	12.	13.	13.
Ethylbenzene	706.	1,100.	650.	82.	ND	26.	ND	ND	ND	ND	ND	ND
Mercury	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Napthalene	ND	94.	49.	ND	ND	1.9	ND	ND	ND	ND	ND	ND
Phenol	914.	2,000.	4,400.	570.	ND	280.	ND	ND	ND	ND	ND	ND
Toluene	14,400.	22,400.	15,600.	1,500.	ND	544.	ND	ND	0.9	ND	ND	ND

Source: CMA 1980

TABLE 3. CONVENTIONAL POLLUTANTS IN THE LIPARI LANDFILL LEACHATE

Parameter[a]	Sampling Date	
	16 April 1980	14 May 1980
BOD	392	468
COD	799	1050
TSS	75	755
TDS	500	-
TKN	31	27
NH_3N	24	24
pH (units)	5.2	6.35
Specific Conductance (mhos/cm)	942	-
Chloride	154	192
Cyanide	-	0.03

[a] All values in mg/l unless otherwise noted.

Source: REWAI 1980

TABLE 4. METALS IN THE LIPARI LANDFILL LEACHATE

Parameter[a]	16 April 1980	14 May 1980	Priority Metal (X)
Aluminum	0.6	–	
Antimony	<0.2	<0.2	X
Arsenic	0.0128	0.008	X
Barium	<0.1	–	
Beryllium	0.03	0.026	X
Cadmium	<0.005	<0.005	X
Calcium	27	–[b]	
Chromium	<0.05	0.035	X
Cobalt	0.19	–	
Copper	0.1	<0.02	X
Iron	100.4	352.6	
Lead	0.14	0.026	X
Magnesium	<0.001	–	
Manganese	0.56	0.69	
Mercury	0.0029	0.0025	X
Molybdenum	<0.1	–	
Nickel	<0.04	0.15	X
Potassium	59.2	–	
Selenium	<0.002	<0.002	X
Silver	<0.01	<0.01	X
Sodium	43	–	
Strontium	0.1	–	
Thallium	<0.1	<0.1	X
Tin	<0.8	–	
Titanium	<0.4	–	
Vanadium	<0.2	–	
Zinc	0.067	0.068	X

[a] All values in mg/l.

[b] Test with lower detection limit used on second sample.

Source: REWAI 1980

TABLE 5. ORGANICS IN THE LIPARI LANDFILL LEACHATE

GROUP	CLASS	COMPOUND[a]	4/16/80	5/14/80
Volatiles	Chlorinated alkanes	Methylene chloride	990	*
		Chloroethane	19	34
		1,1- Dichloroethane	43	76
		1,2- Dichloroethane	5,800	-
		1,2- Trans Dichloroethylene	12	12
		Vinyl chloride	81	120
		Trichloroethylene	12	-
		1,1- Dichloroethylene	*	-
		Tetrachloroethylene	*	-
	Chlorinated aromatics	Chlorobenzene	26	88
	Aromatics	Benzene	430	1,200
		Toluene	3,100	17,500
		Ethyl benzene	880	1,600
	Miscellaneous	Acrolein	-	16
		Acrylonitrile	-	*
Base Neutral Extractables	Aromatics	Naphthalene	100	18
	Phthalate esters	Bis (2-Ethylhexyl) phthalate	12	-
		Diethylphthalate	28	*
		Di-N-butylphthalate	*	-
	Chlorinated aromatics	1,2-Dichlorobenzene	70	-
		1,2,4-Trichlorobenzene	-	*
	Chlorinated ethers	Bis (2-chloroethyl) ether	22,000	440
		Bis (2-chloroisopropyl) ether	-	80
Acid Extractables	Phenols	Phenol	5,500	1,000
Pesticides				

[a]All values in ppb.

*<10 ppb.

Blank = Not detected.

Source: REWAI 1980

(5) Data regarding the rate at which contaminated groundwater could be purged from the aquifer.

A critical phase of this hydrogeologic investigation involved the installation of 25 test borings and wells throughout the site area. Eighteen test wells were installed at 14 locations above the Chestnut Branch embankment (Figure 7). These wells have been designated as the C-series. Thirteen of these C-series wells were screened in the Cohansey Sand and five were screened in the Kirkwood Sand which directly underlies the Kirkwood clay strata. All 18 wells penetrated the clay unit at least five feet to confirm its spatial continuity. In addition, seven wells, designated as the D-series, were placed in the Chestnut Branch marsh to a depth of about three feet to define the extent of contamination there (see Figure 7).

A total of 30 groundwater samples were collected and analyzed under the supervision of EPA's Office of Research and Development (ORD). Groundwater samples were analyzed for three organic chemical fractions: the acids and base/neutral fraction, aromatics, and halogens. Table 6 gives the distribution and concentration levels of these groups of compounds identified across the site. The compounds that fall within each of the three groups are as follows:

- Acids and base/neutrals: phenol, bis (2-chloroethyl) ether and bis (2-chloroethoxy) ethane
- Aromatics: benzene, toluene, ethyl benzene, p&m-xylene, o-xylene, cumene
- Halogenated hydrocarbons: methylene chloride, 1,2-dichloroethane, 1,1-dichloroethane, trans-1,2-dichloroethylene, tetrachloroethylene.

The reader is referred to Appendix D of REWAI (1981a) for the distribution of specific compounds in groundwater samples. The following conclusions were drawn from the analytical results:

- Total organic concentrations (TOC) decreased toward the northeastern embankment, probably because of dilution and dispersion.
- There was a tendency for the aromatic fraction to comprise the major part of the total organic load within a few hundred feet of the landfill, and to comprise a smaller proportion further away.

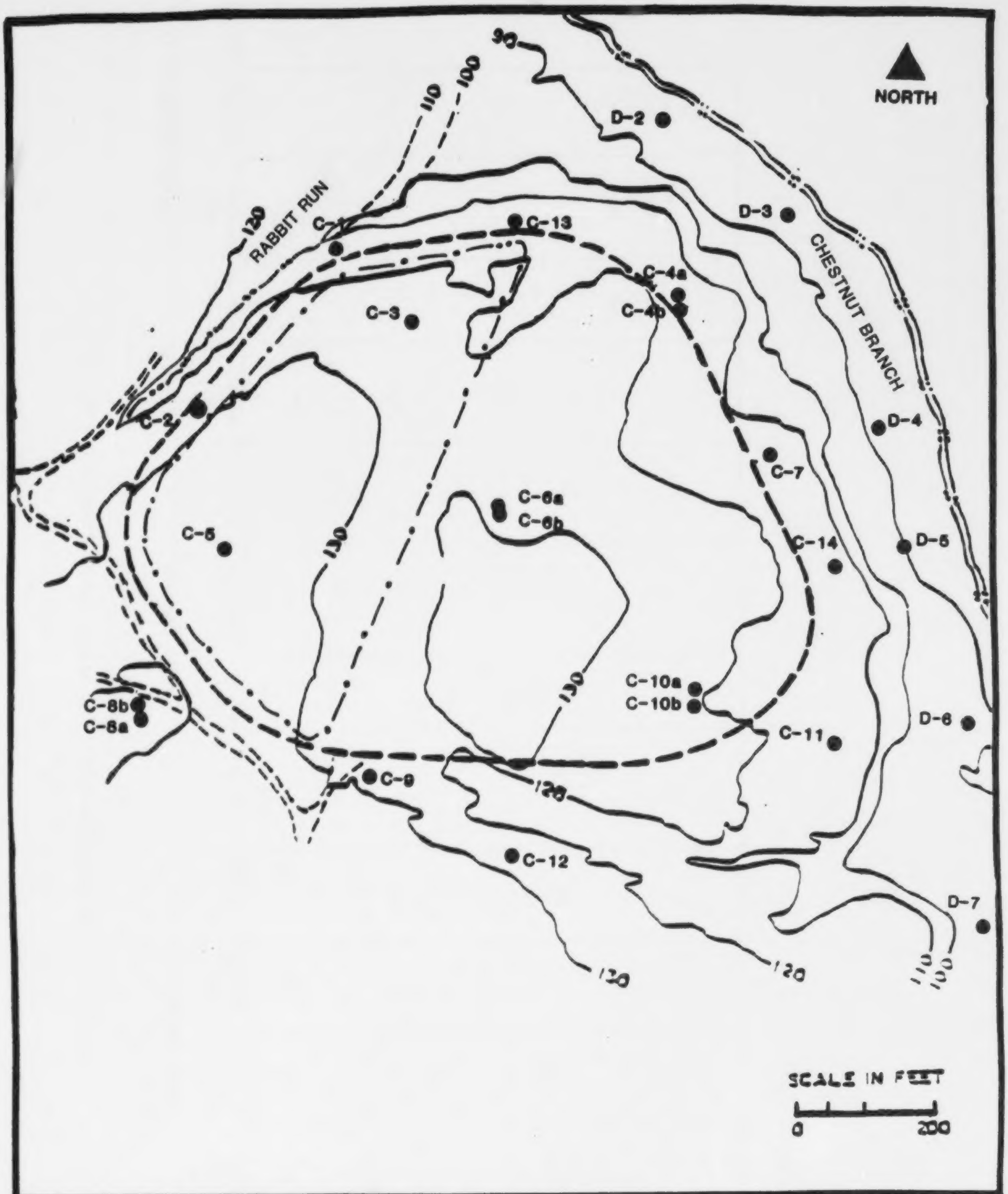


Figure 7. Local Setting of the Lipari Landfill Showing the C–Series and D–Series Wells

Source: REWAI 1981a

TABLE 6. GROUNDWATER ANALYSES FROM LIPARI LANDFILL (ppb;ug/1)

	UPPER COHANSEY				LOWER COHANSEY				KIRKWOOD	MARSH SEDIMENTS			
Well ID	Total Organics	Acids Base/ Neutrals	Aromatics	Halogens	Total Organics	Acids Base/ Neutrals	Aromatics	Halogens	Total Organics	Total Organics	Acids Base/ Neutrals	Aromatics	Halogens
C-1					>113	66	46	0.6	18				
C-2	24	0	24	0.05									
C-3									199				
C-4a													
C-4b					39	0	39	0.8	424				
C-5	78	8.1	69	1.2	0	0	0	0					
C-6a	257												
C-6b		47	160	49					14				
C-7	183	91	80	12									
C-8a		0	0	0	0				0				
C-8b						0	0	0					
C-9					0	0	0	0					
C-10a													
C-10b					>60	>56	3.8	0.2	0.7				
C-11					9	0	6.5	2.3					
C-12	0.1	0	0.1	0		0	0	0					
C-13	187	0	101	86	177	0	109	68					
C-14					94 -123	0	122	0.5					
D-2										24	130	76	28
D-3										53	0	51	2.3
D-4										29	11	17	0.6
D-5										11	0	10.9	0
D-6										57	39	17	1.2
D-7										0	0	0	0

Source: REWAI 1981b

- The areal distribution of each fraction tended to be similar in both the Upper and Lower Cohansey Sands.

- High TOC concentrations in the Kirkwood Sand were believed to be caused by artificial leakage created by the drilling process.

- TOC levels in the Chestnut Branch marsh were about the same as the levels found in groundwater of the Cohansey Sand on the embankment.

- The average concentration of organic compounds being released from the embankment by the Cohansey Sand was approximately 185 ppm (mg/l).

In addition to contamination of the immediately surrounding surface water and groundwater, the Lipari Landfill has also affected Alcyon Lake located about 1000 feet (305 m) downstream. Previously used as a recreational area for residents, Alcyon Lake was closed to public and private use by the Gloucester County Health Department in 1980 because both water and fish were contaminated with the suspected carcinogen BCEE. In 1983, EPA completed a study on the limnological conditions of the lake. The purpose of the study was to document baseline conditions of the lake and to develop a monitoring program to evaluate the effectiveness of remedial activities at the Lipari Landfill. During the summer and fall of 1982, two sets of water samples were collected and analyzed. Analyses' results from both sets of water samples showed BCEE and 1,2-bis(2-chloroethoxy)ethane (1,2BIS) to be present in the highest concentrations (>50 ppb; ug/l). The two sample sets showed that BCEE and 1,2BIS were in the water column in similar concentrations and that their concentrations varied similarly with respect to distance from the landfill (Radian 1983b). Table 7 lists the organic chemicals in samples collected from Alcyon Lake.

The major hazard associated with the Lipari Landfill has been the presence of relatively high concentrations of BCEE in the leachate discharge, and in ground- and surface water. BCEE is of particular concern because it is a suspected human carcinogen and is related to a class of known animal carcinogens called beta chloroethers (Fred C. Hart Associates, Inc., 1982). Data showed concentrations of BCEE in surface water as high as 210,000 ppb (ug/l) at leachate seeps. Concentrations of BCEE found in groundwater on-site were as high as 88,000 ppb (ug/l) (REWAI 1981a).

TABLE 7. SAMPLE ANALYSIS RESULTS FROM ALCYON LAKE

SAMPLING SET #1

Compound	Substrate	Concentration Range (ug/l)(ppb)
Methylene chloride	Fish[a]	0.03-0.04
Benzene	Fish[a]	0.001-0.60
Diethyl phthalate	Fish	0.06
Di-n-butyl phthalate	Fish	0.30-0.70
Bis (2-ethyl hexyl) phthalate	Fish	12-13
Di-n-octyl phthalate	Fish	8
Methylene chloride	Water[a]	< 1.0-40
Di-n-butyl phthalate	Water[a]	< 1.0-60
Bis (2 ethyl hexyl) phthalate	Water[a]	17-300
Bis (2 chloroethyl) ether	Water	35-68
Phenol	Water[a]	1.0
Bis (2 ethyl hexyl) phthalate	Sediment[a]	3.0-40
Di-n-octyl phthalate	Sediment[a]	1.0-35
3,3,5-Trimethylcyclohexanol	Water	10
Cyclohexanone	Water[a]	20
1,2,bis (2-chloroethoxy) ethane	Water	45-70

[a] Found in upstream control and/or method blank.

SAMPLING SET #2

Compound	Substrate	Range (ug/l)(ppb)
Bis (2 chloroethyl) ether	Fish	0.04-0.08
Bis (2 ethylhexyl) phthalate	Fish	0.04-2.0
Butyl benzyl phthalate	Fish	0.2
Di-n-butyl phthalate	Fish	3.0-3.1
Bis (2 chloroethoxy) ethane	Fish	0.06
Bis (2 chloroethyl) ether	Water	16-103
Bis (2 ethyl hexyl) phthalate	Water[a]	2.0-9.0
Di-n-butyl phthalate	Water[a]	1.0-4.0
Butyl benzyl phthalate	Water[b]	2.0
Benzene	Water[b]	3.1
1,2, dichloroethane	Water[b]	1.9
Methylene chloride	Water[b]	1.4
Toluene	Water[b]	1.2
Bis (2 chloroethoxy) ethane	Water	50-140

[a] Values greater than 100% = found in upstream control.

[b] Only presesnt at confluence of Rabbit Run and Chestnut Branch.

Source: Radian 1983a

PLANNING THE SITE RESPONSE

Initiation of Site Response

In July 1971, the New Jersey Department of Environmental Protection (NJDEP) ordered Mr. Lipari to correct the leachate discharge problem which had been observed since 1970. In an effort to correct the problem, he consulted engineers, constructed a broad surface water diversion ditch along the southern boundary of the site, regraded areas of the landfill, and spread fresh soil and lime on the site. These efforts failed to control the leachate discharge, and consequently, Mr. Lipari was sued by NJDEP for violation of the New Jersey Water Quality Act (N.J.S.A. 58:10-23.1 et seq., hence repealed and replaced by the Water Quality Planning Act 58:11A-1 et seq.; and N.J.A.C. 7:26-1). The court entered a final order in October 1974 requiring Mr. Lipari to cease and desist from polluting the Chestnut Branch within 180 days, and to lime and landfill surfaces in accordance with NJDEP's instructions. After the issuance of the cease and desist order, Mr. Lipari undertook additional remedial actions; these also had little effect in mitigating the leachate flow.

Pursuant to the matter, on September 9, 1980, the court ordered Mr. Lipari to construct a fence around the site by October 25, 1980, and to refrain from excavating and farming the landfill. When this was not accomplished, EPA took action under Section 311 of the Clean Water Act to limit access to the site. Sequestering of the landfill was accomplished with the installment of 3,438 linear feet (1,048 m) of 8-foot (2.4-m) high chain link fence in July 1982, under the direction and funding of the Emergency Response and Hazardous Materials Inspection Branch of the U.S. Environmental Protection Agency, Region II.

In the spring of 1983, 19 new groundwater monitoring wells were installed at the site to be utilized under an ORD-designed sampling program. The program is designed to assess the effectiveness of the remedial actions implemented at the site.

Design and draft specifications for a slurry cut-off wall and cap containment system were produced, reviewed, and revised after a Superfund State Contract between the NJDEP and the EPA was signed on September 23, 1982. Construction of the slurry wall was initiated in the summer of 1983 under the supervision of the U.S. Army Corps of Engineers.

Selection of Response Technologies

The selection of response activities and technologies at the Lipari Landfill first began in 1971 when Nick Lipari was notified by NJDEP of his duty to correct the situation at the site. In response to the state notification, Mr. Lipari consulted engineers, constructed ditches to divert surface water, regraded areas of the landfill, and spread fresh dirt and lime in an attempt to correct the problem. The effort was not successful. Mr. Lipari undertook additional remedial steps in response to a 1974 court order which included liming the surface water and filling the low, swampy areas. These efforts did not reduce leachate flow either.

300.68(e)(1)
initial measures

Over the next five years, following Mr. Lipari's efforts, various minor investigations were conducted at the site, but a comprehensive study was not completed. Abatement alternative studies were not initiated until local government officials focused their attention on the problem in the late 1970s.

The first comprehensive Lipari Landfill study conducted was directed by EPA and involved the review of all previously compiled data and subsequent assessment of alternative courses of action to correct the problem. The final report, completed in February 1980, included a site assessment based on data from previous investigations, recommendations for further studies, and descriptions of alternative short-range remedial actions.

The following abatement alternatives were considered:

- Leachate Collection
  - Subdrain collection system
  - Open-ditch collection system
  - Wellpoint collection system
- Leachate Treatment
  - Off-site incineration
  - Off-site Publicly Owned Treatment Works (POTW) treatment
  - On-site treatment by carbon adsorption
  - Steam distillation
  - On-site treatment by recycling
- Site Closure
  - Relocation of waste material
  - In situ encapsulation/slurry wall construction.

The report discussed these alternatives and recommended that selection await a detailed hydrological and geological survey of the site.

In April 1980, a feasibility study of short-term abatement alternatives for the Lipari Landfill leachate problem was initiated by EPA Region II. The study utilized both old and newly generated leachate character and hydrogeological data. The purpose of the study was to select alternatives that would provide a significant degree of relief from the problem, while a comprehensive, long-term abatement system was designed and implemented at a later date. The three types of abatement systems evaluated were: leachate collection, leachate containment, and leachate treatment. The final report, completed in October 1980, made the following recommendations:

- A difference did not exist, in terms of capital costs, between viable short-term and long-term abatement programs, therefore a comprehensive long-term program should be selected and implemented.

- A full-scale, 16-acre (6.5-ha) slurry wall and cap encapsulation plan should be implemented to contain the zone of contaminated groundwater.

- Additional hydrogeologic investigations must be conducted to define subsurface conditions in more detail.

- Abatement alternatives selected should not be treatment-intensive because of expense and long-term commitment.

In September 1981, a second report was completed for EPA. This report was prepared following a technical field investigation and further assessment of response technologies. The field investigation was primarily designed to facilitate the construction of a cutoff wall around the zone of contaminated groundwater which was recommended in the 1980 report. This recommendation was based on the existence of the relatively impermeable clay layer beneath the site area, into which the wall could be keyed. During this investigation, the C- and D-series wells discussed earlier were installed in the landfill area. The recommended abatement system in the 1981 report included the construction of a slurry wall enclosing an area of about 15 acres (6 ha) using the vibrating beam method. Inside this area, a laterally vibrated beam slurry wall would be constructed, isolating the drum disposal locations from the remaining contaminated areas. In addition,

300.63(a)(2)
investigation

an interior leachate collection, treatment, and flushing system, and an impervious cap were recommended. Later, in 1983, however, the vibrated-beam construction method was refuted for use at this site by the design consultants, the Army Corps of Engineers (ACE), EPA, and the State, because of the uncertainties in wall integrity it yields compared to the slurry trench technique (see Table 9 for details).

In January 1982, the consultant to the responsible parties submitted a new alternative cleanup plan to EPA's 360° cutoff wall proposal. This alternative consisted of an upgradient, 180° slurry cutoff wall, a groundwater interception drain and swale upgradient of the cutoff wall, the installation of an impermeable liner to serve as a cap over a 22-acre (9-ha) area, and a gas venting system. This alternative was evaluated in the final assessment (see Table 9, Alternative 9, for details).

Before EPA Region II's September 1981 study was complete, another party became more visibly involved in the Lipari Landfill situation: EPA's Office of Research and Development (ORD). In June 1980, a four-year contract was awarded to a contractor by ORD to prepare a manual on hazardous waste site clean-up activities, in which the Lipari Landfill was being used as a case study. Under this contract, additional studies at the landfill were funded and ORD was given the responsibility of managing the drilling and sampling programs, and the monitoring and the evaluation of the long-term efficiency of the remedial action.

As a result of the passage of CERCLA and following the submission of the responsible party's new alternative in January 1982, EPA Region II and EPA/ORD together initiated a cost-effectiveness analysis of remedial alternatives studied previously under the direction of EPA Region II in 1980 and 1981. This analysis included the responsible party's alternative, and the preparation of an Environmental Information Document to comply with CERCLA requirements. The analysis involved the evaluation of 16 basic alternatives. For those alternatives that included groundwater treatment, three treatment options were evaluated. The consideration of these treatment options produced a total of 32 alternatives that were assessed. These alternatives are listed in Table 9.

300.68(g)
development of
alternatives

TABLE 8. THIRTY-TWO REMEDIAL ALTERNATIVES, LIPARI LANDFILL

1.	No action.
2(a).	Collect with shallow trench/Treat with granular activated carbon.
2(b).	Collect with shallow trench/Treat with on-site biological oxidation.
2(c).	Collect with shallow trench/Treat at POTW.
3(a).	Collect with deep trench/Treat with granular activated carbon.
3(b).	Collect with deep trench/Treat with on-site biological oxidation.
3(c)	Collect with deep trench/Treat at POTW.
4.	Collect with perimeter wells.
5.	Upgradient deflection wall with cap (6 acres).
6(a).	Upgradient deflection wall with cap (6 acres)/Collect with wells/ Treat with granular activated carbon.
6(b)	Upgradient deflection wall with cap (6 acres)/Collect with wells/ Treat with on-site biological oxidation.
6(c).	Upgradient deflection wall with cap (6 acres)/Collect with wells/ Treat at POTW.
7.	360° Cutoff wall with cap (6 acres).
8.	360° Cutoff wall with cap (16 acres).
9(a).	360° Cutoff wall with cap (6 acres)/Collect with Wells/Treat with granular activated carbon.
9(b).	360° Cutoff wall with cap (6 acres)/Collect with wells/Treat with on-site biological oxidation.
9(c).	360° Cutoff wall with cap (6 acres)/Collect with wells/Treat at POTW.
10(a).	360° Cutoff wall with cap (16 acres)/Collect with wells/Treat with granular activated carbon.
10(b).	360°Cutoff wall with cap (16 acres)/Collect with wells/Treat with on-site granular biological oxidation.
10(c).	360° Cutoff wall with cap (16 acres)/Collect with wells/Treat at POTW.
11(a).	360° Cutoff wall with cap (16 acres)/Internal wall/Flush/Collect with wells/Treat with granular activated carbon.
11(b).	360° Cutoff wall with cap (16 acres)/Internal wall/Flush/Collect with wells/Treat with on-site biological oxidation.
11(c).	360° Cutoff wall with cap (16 acres)/Internal wall/Flush/Collect with wells/Treat at POTW.
12(a).	Collect with wells/Treat with granular activated carbon.
12(b).	Collect with wells/Treat with on-site biological oxidation.
12(c).	Collect with wells/Treat at POTW.
13.	Remove and dispose of waste off-site.
14.	Deflection wall/Upgradient drain/Cap (22 acres).
15(a).	Deflection wall/Upgradient drain/Cap (22 acres)/Collect with wells/ Treat with granular activated carbon.
15(b).	Deflection wall/Upgradient drain/Cap (22 acres)/Collect with wells/ Treat with on-site biological oxidation.
15(c).	Deflection wall/Upgradient drain/Cap (22 acres)/Collect with wells/ Treat at POTW.
16.	Deflection wall/Upgradient drain/Cap (22 acres)/Collect with deep trench/Treat at POTW.

Source: Radian 1982b

The evaluation of each remedial alternative was developed in terms of the following factors:

300.68(h) screening

- Construction cost
- Operating and maintenance cost
- Achievable level of cleanup
- Time needed to achieve cleanup
- Feasibility
- Implementability
- Reliability
- Ability to minimize adverse impacts
- Remoteness of activities
- Usability of land after action
- Need for further study
- Usability of lake after action.

The analyses resulted in the identification of highly cost-effective alternatives.

Following the completion of the cost-effectiveness analyses, an Environmental Information Document (EID) was prepared for the Lipari site (Radian 1982). The EID is an analysis report which focuses on the environmental consequences of each alternative in order to determine which of the cost-effective alternatives would have the least negative environmental impact. The Lipari EID includes detailed descriptions of the nine highly cost-effective alternatives, one of which was selected as the preferred action, plus the "no action" option. These 10 final remedial alternative scenarios are listed in Table 9, which describes each alternative and gives the rationale for either its rejection or acceptance as the action to be implemented at the Lipari site. In addition, Table 9 describes the alternative methods of wall construction and alternative capping materials considered during the analysis process. These also are described in terms of the rationale for either their rejection or acceptance.

300.68(i)(2)(E) analysis and mitigation of adverse environmental impacts

Following the selection of the nine most cost-effective "action" alternatives, further evaluation by EPA staff at both the Region and Headquarters, with technical assistance provided by the zone contractor and information contained in the EID, led to further elimination of alternatives as environmentally unacceptable except for the following three:

- 360° cutoff wall with cap (16 acres; 6.5 hectares), collect with wells and treat at POTW

- 360° cutoff wall with cap (16 acres; 6.5 hectares)

TABLE 9. FINAL TEN ALTERNATIVE RESPONSE TECHNOLOGIES FOR MITIGATION OF LEACHATE DISCHARGE PROBLEM AT LIPARI LANDFILL

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP References
1. No action (r)	No remedial action taken at the site.	• No level of cleanup achievable within an acceptable timeframe • Leaching would continue to surface waters indefinitely • No control of plume area • No isolation of wastes.	
2.* 360°F cutoff wall and cap (16 acres; 6.5 ha) collect with wells/treat at POTW/ gas venting system(a)	Two-phased approach to implementation: I. Subsurface soil-bentonite barrier wall constructed around landfill and contaminated plume areas (16 acres; 6.5 hectares); II. Collect contaminated groundwater within confines of wall and cap, treat at local POTW and discharge (yet to be implemented). Objectives: • Immediately and efficiently eliminate discharge of leachate to surface waters • Reduction of leachate generation by barring rainfall percolation into landfill and plume areas • Actively mitigate problem by removing and treating contaminated groundwater from confines of wall and cap.	• Discharge of leachate to surface water is immediately halted • Wastes completely isolated • Immediate reduction of leachate generation • Isolation of landfill area (6-7 acres; 2-3 ha) and contaminated plume area (10 acres; 4 ha) • Collection/treatment of contained groundwater improves reliability of containment • Insignificant operation and maintenance (O&M) costs for Phase I.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(A) surface seals 300.70(b)(2)(iii)(c) groundwater pumping 300.70(b)(2)(ii)(A)(1) conventional wastewater treatment
2a. Trench excavation construction technique (a)	Barrier wall constructed by trench excavation and backfill method: trench excavation using slurry to keep trench open. Backfill introduced, displacing slurry.	• Penetration or key-in of wall into impermeable clay layer is ensured by visual inspection • Width of wall can be decided upon	

(continued)

*One of the final three alternatives evaluated.
(r) = rejected alternative.
(a) = accepted alternative.

TABLE 9. (continued)

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP References
2a. Trench excavation (cont'd.)	Backfill composition: soil-bentonite Width: $\geq$ 30 inches (7.6 cm) Depth: Between 30 and 52 feet (9 and 16 m) (at least 2 feet (0.6 m) below top of clay liner) Permeability: 3.2×10^{-9} ft/sec (1×10^{-7} cm/sec) Configuration: 360° (16 acres; 6.5 hectares)	• Use at other hazardous waste sites has been successful • Potential for gaps or windows in wall is very small if proper inspections are made during construction. • Rejected subsequently during remedial design process	
2b. Vibrated beam construction technique (r)	Barrier wall constructed using crane suspended I-beam through which an asphalt emulsion is injected into ground in panels; every injected panel is overlapped by the following insertion as rig moves continuously around site.	• Impossible to ensure continuity of wall because difficult to maintain plumbness of beam, i.e. potential for "windows" or openings in wall higher than for slurry trench cutoff wall. • Cannot ensure sufficient penetration into clay because cannot visually inspect during construction • Method has been infrequently used at hazardous waste sites; reliability unproven.	
2c. Synthetic membrane liner (a)	High-density polyethylene (HDPE) liner material transported to site in large rolls. Rolls laid out and welded together to form one continuous cover.	• Cost of installation for contractor less than if clay materials were used	300.70(b)(1)(ii)(A) surface seals
2d. Clay liner (r)	Clay soil to cover 16-acre (6.5-ha) site.	• Rejected during competitive bidding process because of higher cost • High costs for overall installation • Just as technically feasible as synthetic liner, however, due to clay having to be imported to site, costs were higher for contractor.	

(continued)

*One of the final three alternatives evaluated.
(r) = rejected alternative.
(a) = accepted alternative.

TABLE 9. (continued)

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP References
3. Deflection wall and cap (6 acres; 2.4 hectares) (r)	Partial slurry trench cutoff wall installed along upgradient sides of landfill and clay cap over 6-acre (2.4-ha) waste disposal area Objectives: • Deflection of groundwater movement around landfill to reduce leachate generation.	• Only gradual reduction in leachate discharge to surface waters • No active mitigation of problem, i.e. no removal or treatment of contaminated groundwater • Contaminated plume area (10 acres; 4-ha) not addressed.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(6) surface seals
4. Deflection wall and cap (6-acre; 2.4-ha)/collect with wells/treat at POTW (r)	Same as alternative 3, with addition of wells to intercept groundwater moving around the wall ends. Objectives: • Deflection of groundwater movement around landfill to reduce leachate generation • Collection of groundwater to reduce leachate discharge to surface waters.	• Only partial isolation of contaminated area • No control of contaminated plume area • Treatment-intensive, very expensive • Time for treatment studies necessary during which no reduction of leachate discharge would occur.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(A) surface seals 300.70(b)(2)(iii)(c) groundwater pumping 300.70(b)(2)(ii)(A)(1) conventional wastewater treatment
5. 360° cutoff wall and cap (6-acre; 2.4-ha) (r)	Subsurface barrier wall installed around waste disposal area; clay cap to reduce infiltration. Objectives: • Reduce leachate generation by isolation of landfill.	• No containment of contaminated plume • Only gradual decrease in leachate discharge to surface waters • No active protection options involved; i.e. pumping and treatment.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(A) surface seals

(continued)

*One of the final three alternatives evaluated.
(r) = rejected alternative.
(a) = accepted alternative.

TABLE 9. (continued)

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP References
6.* 360° cutoff wall and cap (16 acres; 6.5-ha) (r)	Subsurface barrier wall installed around landfill and contaminated plume areas, and cap (16 acres; 6.5-ha). Objectives: • Reduce leachate discharge to surface waters • Reduce leachate generation by isolation of landfill.	• Only passive control of landfill and contaminated areas; i.e. contaminated groundwater remains on-site.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(A) surface seals
7. 360° cutoff wall and cap (6 acre; 2.4-ha)/collect with wells/treat at POTW (r)	Identical to alternative 5 with a 10-well pattern and connection to POTW. Objectives: • Reduce leachate generation • Actively mitigate problem by collection, treatment of groundwater.	• Contaminated plume is not isolated • Groundwater can move into the plume area farther upgradient • Only gradual reduction of leachate discharge to surface water • Time required for treatment studies which is time without active mitigation.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(A) surface seals 300.70(b)(2)(iii)(c) groundwater pumping 300.70(b)(2)(ii)(A)(1) conventional wastewater treatment
8. Collect with wells/treat at POTW (r)	No deflection/encapsulation systems are installed; use of a ten-well pattern pumping at 10 gpm per well as long as dewatering doesn't occur; well spacing is ± 200 feet (61 m); treatment of collected contaminated groundwater at local POTW. Objectives: • Actively mitigate problem by removal and treatment of contaminated groundwater.	• No isolation of wastes, no reduction of leachate generation • Gradual reduction in leachate discharge to surface waters • Treatment intensive very expensive due to operation and maintenance costs • Results not immediate • Treatment studies necessary before POTW would accept leachate; studies would require more time without action being taken at site.	300.70(b)(2)(iii)(c) groundwater pumping 300.70(b)(2)(ii)(A)(1) conventional wastewater treatment

(continued)

*One of the final three alternatives evaluated.
(r) = rejected alternative.
(a) = accepted alternative.

TABLE 9. (continued)

Response Technology Alternative	Description	Rationale for Rejection/Acceptance	NCP References
9. Deflection wall/drain/cap (22 acres; 9-ha)/gas venting system (r)	Upgradient slurry trench cutoff wall with impermeable liner (22 acres; 8.9 ha) and groundwater interception drain and swale upgradient of wall (@ elevation 102'); gas vent installation. Objectives: • Lower water table to level below wastes • Diversion of groundwater in Cohansey Sand around site • Barrier to percolation of rainfall into landfill and contaminated plume area • Reduction in leachate seep volume and concentrations • Release of any gas buildup within landfill area.	• Only gradual reduction of contaminant discharge to surface waters • Only partial isolation of wastes • Only partial containment of contaminated plume • No active means of mitigation; i.e. contaminated groundwater is not being removed or treated.	300.70(b)(1)(iii)(A) impermeable barriers 300.70(b)(1)(ii)(A) surface seals 300.70(b)(iii)(D)(2) drainage ditches
10.* Deflector wall/drain/cap (22 acres; 9-ha)/collect with wells/treat at POTW (r)	Identical to alternative 9 (above) with addition of pumping wells and groundwater treatment Objectives: • Same as alternative 9 (above) and, • Actively mitigates problem with pumping wells located to east of landfill area and treatment at local POTW.	• Only partial isolation of wastes • Only gradual reduction in leachate discharge to surface waters • Contaminated plume remains uncontained • High degree of mitigation depends on implementation of groundwater collection/treatment system and treatment studies necessary before local POTW would accept leachate which require time • Operation and maintenance costs very high.	300.70(b)(2)(iii)(c) groundwater pumping 300.70(b)(2)(ii)(A)(1) conventional wastewater treatment 300.70(b)(1)(iii)(A) permeable barriers 300.70(b)(1)(ii)(A) surface seals 300.70(b)(ii)(D)(2) drainage ditches

*One of the final three alternatives evaluated.
(r) = Rejected alternative.
(a) = Accepted alternatives

- Deflection wall, upgradient drain, cap 22 acres (9 hectares), collect with wells and treat at POTW.

The remedial alternative recommended for implementation at the Lipari Landfill by EPA Region II and the State of New Jersey consisted of two phases. A 360° slurry trench soil-bentonite cutoff wall and high-density polyethylene (HDPE) cap (16 acres, 6.5 ha) was selected as Phase I for the immediate abatement of the problem. Phase II, currently undergoing evaluation, may consist of collection wells for pumping water from within the wall and groundwater treatment at the local POTW. Table 9 describes the selected abatement system and gives the rationale for its selection.

The decision to wall off and cap a 16-acre contaminated area rather than a larger or smaller area was based on cost-effectiveness, the immediate environmental impact, the future prospect of collecting and treating the contaminated groundwater at the nearby POTW, topographical constraints, and limited easements. Containment of the 10-acre (4-ha) contaminated plume area in addition to the landfill area (6 acres; 2.4 ha) increases the system's effectiveness by immediately and significantly reducing leachate discharge to surface waters in addition to the reduction of leachate generation by barring groundwater flow through the landfill. Capping the contained area further reduces leachate generation and reduces the risk of inducing a "bath-tub" effect, because of surface water infiltration in which the enclosed area fills with water and could result in water overtopping the wall. The attractiveness of the selected option, however, is attributed primarily to its second phase which may consist of collecting and treating the contaminated groundwater using the capabilities of the local POTW.

The main considerations leading to the decision by EPA Region II and the State of New Jersey that a leachate collection and treatment system be implemented at the site include:

- Undefined long-term integrity of the cutoff wall.

- Leachate collection would lower the internal head, minimizing infiltration through both the underlying Kirkwood Clay and the wall, and the potential for contamination of the Kirkwood Aquifer.

- The reliability of the containment action would be enhanced by a collection and treatment system at a reasonable cost, thereby providing additional assurance for protection of public health and the environment.

The local POTW treatment option is of interest because of its relatively low cost compared to construction and operation of an on-site treatment system.

Extent of Response

300.68(j)
extent of remedy

The goals for the Lipari Landfill abatement program, agreed upon by EPA and state officials, were to minimize the discharge of leachate to surface water and to mitigate further threat to groundwater. Acceptable levels of discharge were not determined for the performance of the overall containment system prior to its implementation. The purpose of the system is simply to control further contaminant migration off-site in the most economical and environmentally sound manner possible.

DESIGN AND EXECUTION OF SITE RESPONSE

Under EPA's Zone 1 REM Contract, contractor team members provided a predesign report for the slurry wall-cap containment system to be constructed at the Lipari site. This report was followed by detailed draft specifications for construction of the containment system, and a construction and cost schedule.

The following sections describe the design and construction operations conducted at the Lipari Landfill between May 1982 and June 1984.

Remedial actions conducted at the Lipari Landfill consisted of the following activities:

- Installation of a chain link fence around the 16-acre (6.5-ha) site to limit access to the landfill, and installation of a fence along Chestnut Branch to limit access to the contaminated swamp area

- Installation of groundwater monitoring wells to be used for collection of background data and for monitoring the effectiveness and integrity of the slurry trench cutoff wall and cap

- Construction of a soil-bentonite slurry trench cutoff wall around the 16-acre area

- Installation of a synthetic membrane cap system across the 16-acre site (includes drain system and soil cover)

- Installation of a passive gas collection and venting system above the 6 to 7 acres (2.4 to 2.8 ha) that were previously landfilled

- Completion of a contaminated groundwater treatability study and preliminary conceptual evaluation of various collection and treatment systems.

The above remedial activities are discussed in the following subsections.

Chain Link Fence

300.65(b)(3) security fencing

The first action taken at the Lipari Landfill, prior to the installation of monitoring wells and slurry wall construction, was the installation of 3438 feet (1048 m) of 8-foot (2.4-m) high chain link fence around the perimeter of the site. This action was taken because, despite posted warning signs, pedestrians, bikers, and children continued to enter contaminated areas, and once remedial action construction began on-site, it was necessary for health and safety reasons that the area be inaccessible to the public. The original installation of the perimeter fence was completed in July 1982. Minor portions of the fence were later relocated to provide a larger area for construction operations.

In August 1983, a second chain link fence 6 feet (2 m) high and approximately 2300 feet (701 m) long was installed along the Chestnut Branch embankment between the houses to the east and the creek. This action was taken because, again, despite warning signs displayed in the area, residents continued to enter the contaminated swamp areas. The purpose of the second fence was to limit access to contaminated swamp area. Figure 8 shows the approximate locations of these installations.

Groundwater Monitoring Wells

300.68(f) sampling and monitoring

In December 1982, ORD designed and began implementation of a groundwater sampling program to assess the effectiveness of the remedial actions implemented at the site. During April and May of 1983, prior to the construction and installation of the cutoff wall and cap, 19 new wells or wellpoints were installed to monitor groundwater movements and contaminant levels inside and

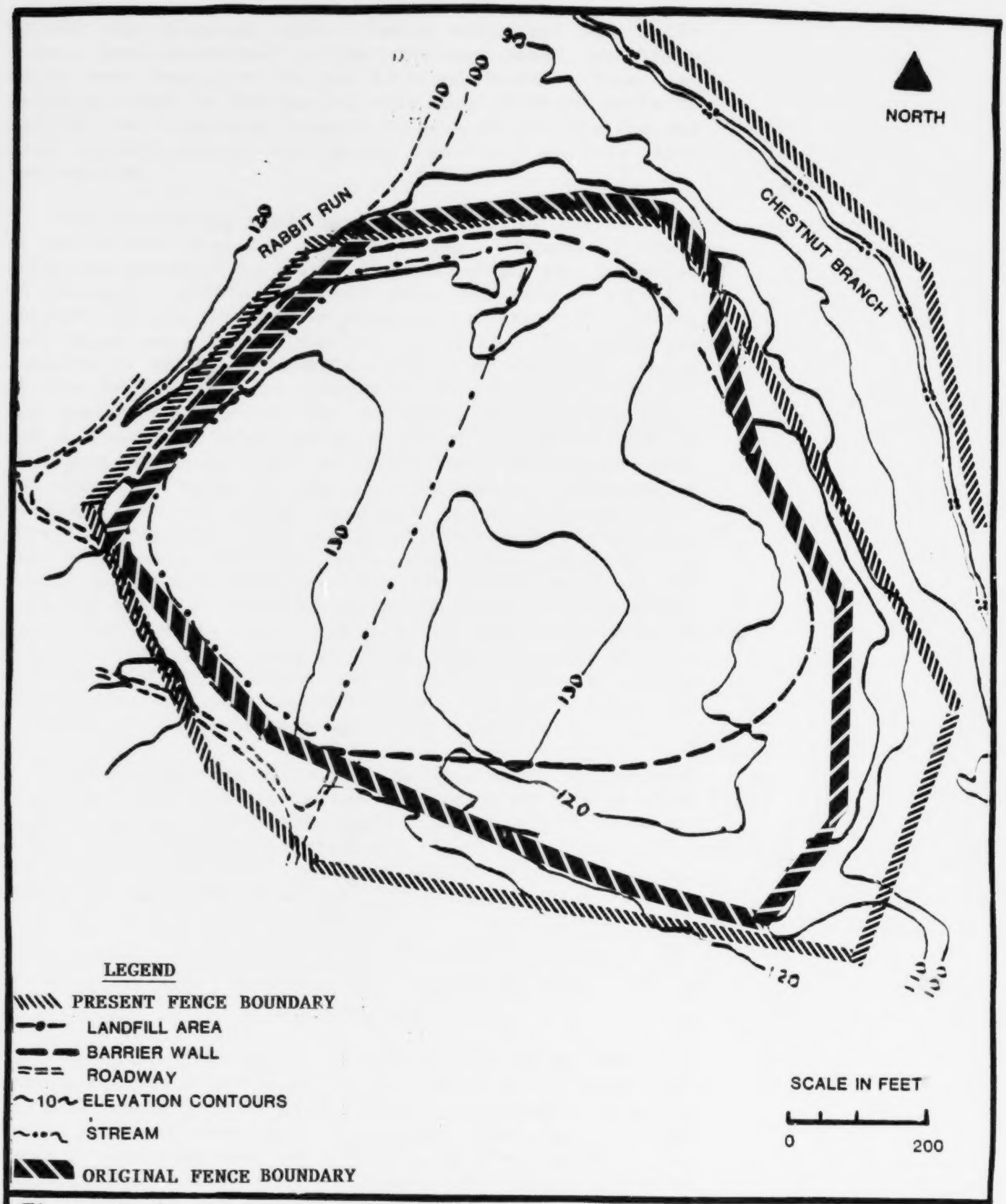


Figure 8. Approximate Locations of Security Fence Installations at Lipari Landfill,NJ

Source: USACE 1984

outside the proposed wall. Twelve wells and four wellpoints were installed in the Cohansey Sands and three wells were installed in the Kirkwood Sands. These new wells are used in conjunction with nine existing wells to monitor the long-term changes in groundwater quality and head levels before and after remedial actions were implemented.

The monitoring plan consists of sampling the 28 wells or wellpoints over the next 2 years. Sixteen of these wells are arranged in pairs situated around the perimeter of the site. Within each well pair, one well is situated outside and one inside the proposed barrier wall. These well pairs were drilled to the top of the clay layer and designed to evaluate the effectiveness of the wall. Seven of the remaining wells penetrate the Kirkwood Sands and are designed to monitor the integrity of the clay layer and indicate if other existing wells not being used in this program have allowed pollutants to leak downward from the Cohansey Sands to the Kirkwood Sands. Four wellpoints, situated along Chestnut Branch valley, will provide additional data on the effectiveness of the wall and yield more complete data about the chemical and hydraulic changes resulting from the installation of the wall and cap. In addition to the 28 wells to be sampled, four 1-inch wells have been left on site and monitored only for head level changes. Data from all wells will be used to evaluate chemical and hydrologic changes inside and outside the containment barrier. Figure 9 gives the location of the monitoring wells and wellpoints.

The 12 Cohansey wells were drilled using hollow stem auger methods and installed through the hollow stem auger's annulus using the auger flights as a temporary casing to prevent hole collapse. Each well is 4 inches (10.2 cm) in diameter, and consists of a 10-foot (3-m) long, 10 slot per inch stainless steel screen with an attached 2-foot (0.6-m) carbon steel, plugged sump, welded to a 4-inch (10.2 cm) nongalvanized steel riser. Stainless steel screens and high carbon steel risers were used because of potential quality assurance questions concerning sampling data if PVC pipes were installed.

The three Kirkwood wells were drilled using hydraulic rotary equipment and methods, following strict decontamination procedures to ensure that contaminants from the Cohansey Sands were not introduced into the Kirkwood Sands. Drilling was accomplished in two phases. The first phase entailed using a 12-inch (30-cm) roller bit to open a hole to the top of the Kirkwood Clay. To ensure accurate delineation of the clay's surface, continuous split spoon samples were taken from about 5 to 8 feet

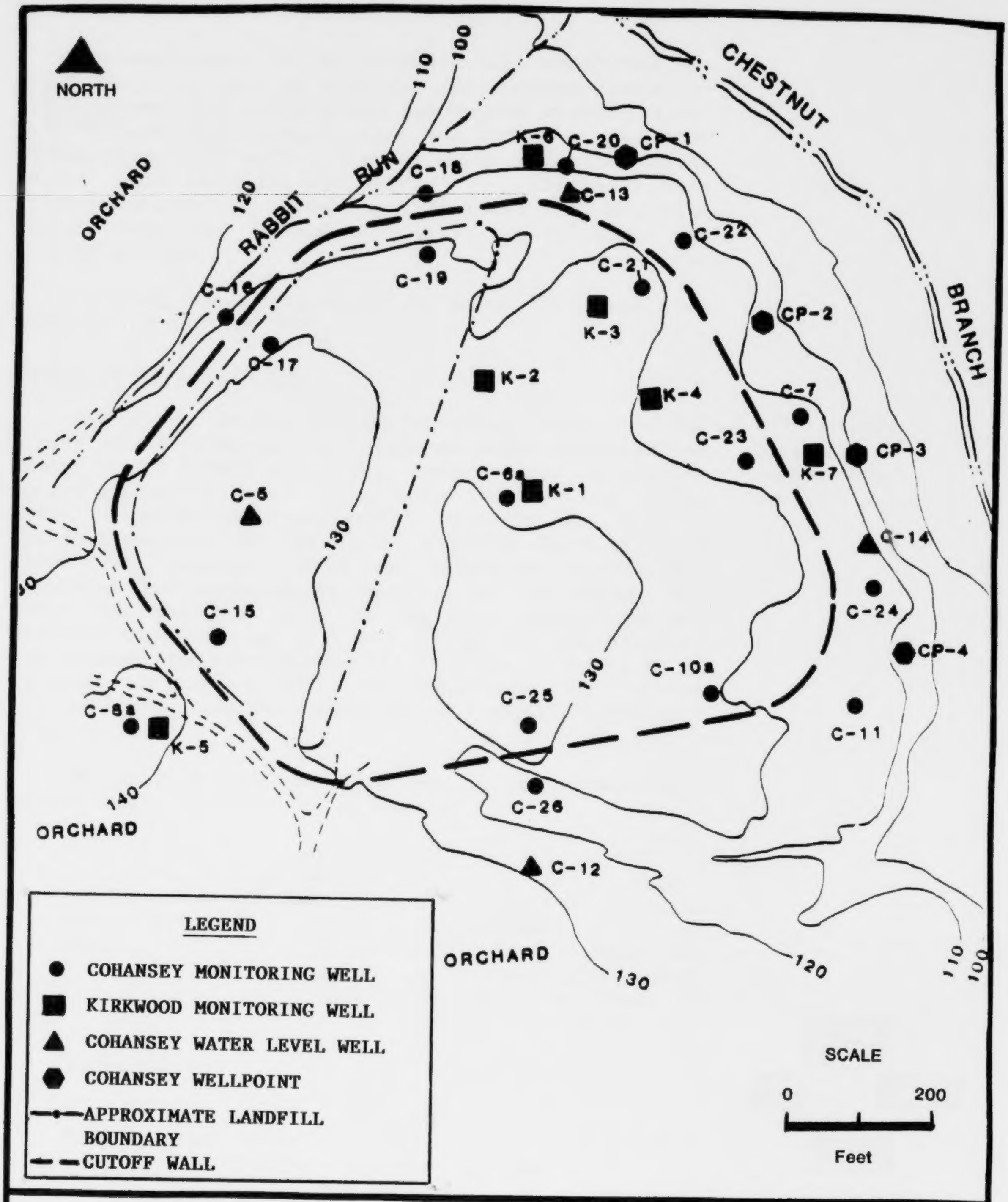


Figure 9. Locations of Monitoring Wells and Well Points at Lipari Landfill, NJ

Source: JRB Associates 1983a

(2-3 m) above the approximate depth of the clay layer until the clay was encountered.

The emplacement of the Kirkwood well components was essentially the same as that for the Cohansey installations, except that (1) threaded and coupled riser pipe was used because well lengths were too long for one-piece installations; (2) well casings extended to greater depths because well installations were deeper; (3) there were differences in the gravel pack heights; (4) bentonite pellets were used instead of slurry; and (5) grout was tremied in place.

Drilling operations began in April 1983, and were completed by mid-May 1983.

Slurry Trench Cutoff Wall

One of the activities funded under Phase I of the Lipari site program was the design and construction of the slurry trench cutoff wall. The Environmental Protection Agency's Zone I contractors performed the predesign evaluation to establish final design criteria for Phase I remedial measures at the Lipari Landfill which included final wall design. Once the predesign report was completed and collectively approved by EPA Region II, NJDEP, and the Army Corps of Engineers (ACE), the ACE oversaw the assemblage of a bid package and the award of the contract for constructing the containment system which included the barrier wall, the impervious cap, the gas venting system, and the monitoring well modifications that were required.

300.70(b)(1)
(iii)(A)
impermeable
barriers

The final design specifications for the construction of the cutoff wall were as follows:

Composition:	Soil-bentonite
Excavation Method:	Slurry trench
Configuration:	360° (16 acres; 6.5 ha)
Width (minimum):	30-inch-wide (76-cm)
Depth:	At least 2 feet (0.6 m) below the top of the Kirkwood Clay; total depth will vary from about 30 feet to 52 feet (9 to 16 m)
Minimum Permeability:	3.2 X 10^{-9} ft/sec (1 x 10^{-7} cm/sec)

Before actual construction began, there were a number of preparatory activities undertaken at the site. The access road was widened and gravelled, and a temporary fence was installed along the road boundaries. Sections of the fence enclosing the site were relocated to allow for more work space along the proposed wall and to provide for the on-site support area. The section that runs along the south boundary was moved further south to make room for a support area, and where the fence ran too close to the proposed wall, as with the western boundary, these sections were also temporarily moved farther away from the proposed wall.

In the support area, two trailers were brought in to be used by the contractor and ACE, a concrete equipment decontamination pad was constructed, a personnel decontamination facility was installed, the slurry and backfill mixing pits were excavated, and a temporary survey tower was set up, as well as temperature and wind recording instruments. Trailers used by ACE were initially located beyond the fence near the intersection of the access road and Route 322, and later moved to the support area.

In addition to staging the support area, a water supply had to be identified. An off-site well, owned by the Zee family, produced water for all site activities. Telephones and electricity were installed in both contractor and ACE trailers. Finally, the site was cleared of all trees and brush. The debris was disposed of on-site, and a working platform was constructed along the alignment of the proposed wall. Figure 10 illustrates how the site was set up for the construction program and will be referred to throughout this section.

Construction activities began on August 15, 1983, and were to be completed by May 11, 1984. The actual start date for wall construction was within just a few days of the proposed date. There was a delay in the commencement of operations because of proceedings involving a slurry wall construction firm's protest to the Comptroller General of the United States of the award of the wall and cap construction contract. The firm felt they had been unjustly excluded from the bid process. The request for bids specified the use of the slurry trench wall construction method. The firm's technique did not qualify as such, and a formal protest followed. Some delay did result until the protest was resolved.

In the second week of October 1983, excavation operations for the construction of the wall began in the south portion of the site. In preparation for the construction program, the work areas in the field were clearly defined and the equipment, operations, and personnel protective requirements within those areas were specified. Two areas were defined, referred to as Exclusion Areas 1 and 2, and included all areas where

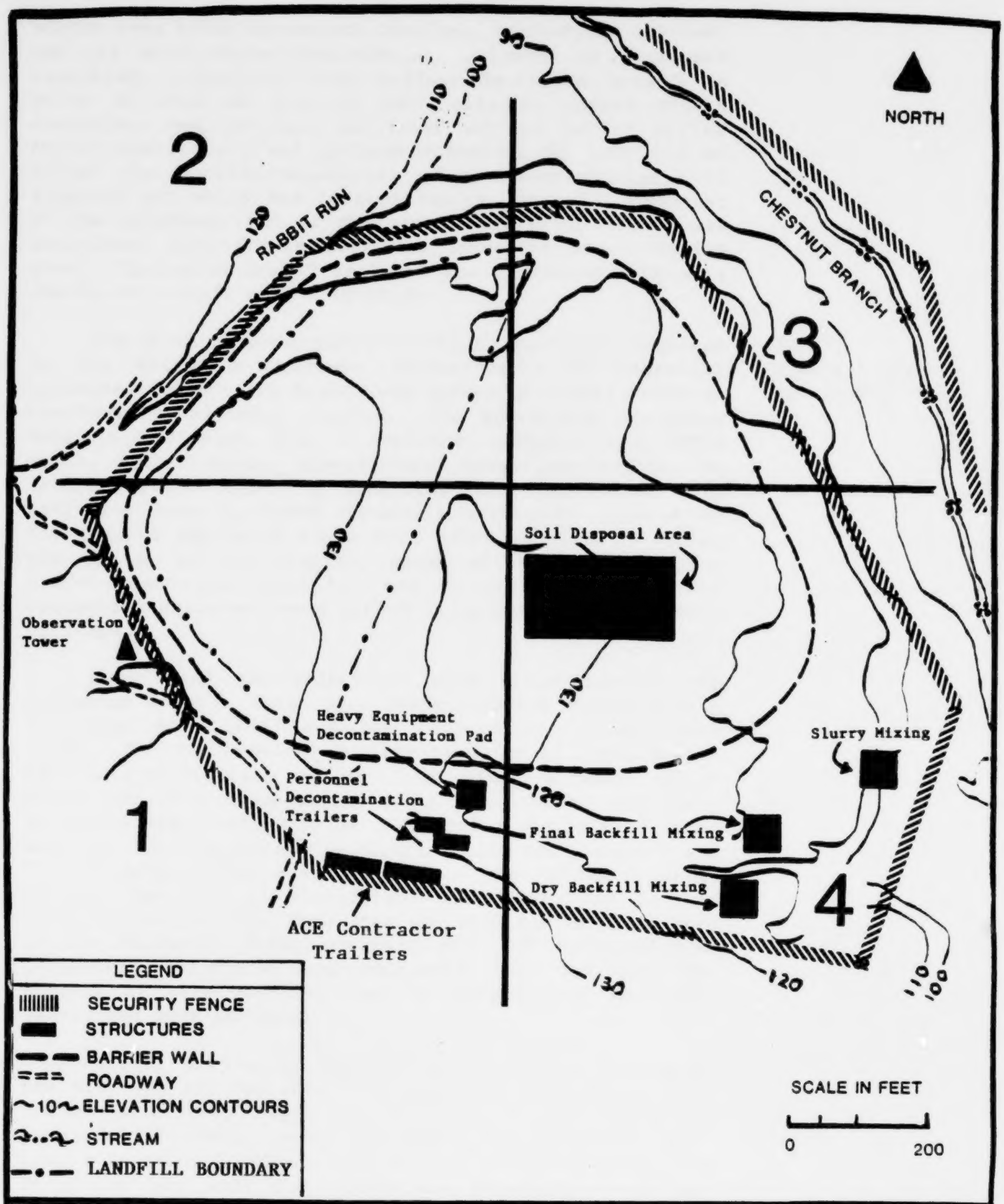


Figure 10. Site Layout for Construction Activities at the Lipari Landfill , NJ

Source: USACE 1984

wastes were being excavated, handled, spoiled, or covered, and all areas where contaminated equipment or personnel travelled. Specifications defined Exclusion Area 1 as being an area 40 feet to each side of active trench operations and 40 feet in front of and behind active trench operations, and an area extending 40 feet (12 m) around the outside boundaries of the contaminated soil disposal pit which was located inside the wall perimeter at the southwest end of the site. Exclusion Area 1 was associated with trench work and therefore was a moving area. Exclusion Area 2 included the remaining work area inside the cutoff wall's location.

300.71
worker health
and safety

The level of personnel protection equipment required in the Exclusion Areas was determined by the industrial hygienist and on-site health and safety personnel based on continuous monitoring results. The protective equipment worn in Exclusion Area 1 included overalls and TYVEK suits, rubber boots, gloves, hard hats, respirators, or self-contained breathing apparatus when necessary. In Exclusion Area 2, heavy coveralls were worn instead of TYVEK suits and respirators were often required. During the course of the program, zones within the Exclusion Areas requiring specific monitoring and personnel protective equipment were marked using either fence, rope, or flags.

There were two additional work areas outside the Exclusion Areas. These were designated the Contamination Reduction Area (CRA) and the Support or "Clean" Area (SCA). The CRA provided for the transfer of construction materials from clean equipment to site-dedicated equipment; for the decontamination of equipment, vehicles, personnel and clothing prior to entering the "clean" area; and for the physical segregation of the "clean" and "dirty" areas. The SCA consisted of the remaining areas outside the zone of significant air, soil, and surface water contamination. This area provided for an entry area to the Exclusion Areas; an exit area for decontaminated personnel, materials, and equipment from the CRA; the housing of site services; and a storage area for clean safety and work equipment.

For the purpose of describing the entire site area, the site was divided into four quadrants (see Figure 10). Trench excavation began in Quadrant 1 and operations proceeded clockwise around the site. One hydraulic backhoe, a Koehring 1066D, with a special 44-foot (13-m) boom extension was used for excavation throughout the construction activities. This piece of equipment had the capability of excavating to a depth of 57.5 feet (17.5 m). The trench was excavated to a depth of at least two feet

(0.6 m) into the underlying Kirkwood Clay. The desired two-foot (0.6-m) keying cut into the clay aquitard was ensured by inspecting samples of excavated material and by routine soundings. The wall ranges in depth from 34 to 54 feet (10 to 16 m) depending on the local depth of the clay deposit. As contaminated soil was excavated from the trench, it was disposed of in a pit that was located in Quadrant 4 (see Figure 10). The soil disposal pit was actually divided into three segments. Two of the segments were 150 feet by 250 feet and about 15 feet deep (46 m x 76 m x 5 m). The third segment was 450 feet by 125 feet and also about 15 feet deep (137 m x 38 m x 5 m).

300.70(c)(2)(i)
excavation of
contaminated
soils

During trench excavation activities in Quadrants 1 and 2 where the wall was situated very close to the landfill's western boundary, trash was encountered within the excavated trench. These findings, although unexpected, caused no significant delay in operations. Wall construction activities were complicated by an elevation change of more than 20 feet (6 m) in a distance of only 1,200 feet (366 m) along the wall's path. To accommodate this difference in elevation, instead of installing an elevated platform and handling an excess of 45,000 cubic yards (34,400 m^3) of material twice, the contractor devised a method using built-up berms (Ward 1984).

As the trench was excavated, it was filled with a bentonite slurry used to stabilize the sides of the trench and maintain their verticality. The slurry consisted of a stable colloidal suspension in water. The bentonite was a pulverized, premium-grade, natural sodium bentonite that met the American Petroleum Institute's (API) "Specifications for Oil Well Drilling Materials" (API Standard 13A). The slurry mixture met the following requirements when tested in accordance with API Standard 13B:

- Minimum 1 pound (454 g) of bentonite per 2 gallons (8 1) of slurry (minimum 5.65%)
- Plastic viscosity $\geq$ 15 centiposes at 68°F (20°C) or $\geq$ 35 seconds Marshal Funnel reading
- Filtrate loss $\leq$ 0.79 inches (20 mm) in 30 minutes at 100 psi
- Specific gravity $\geq$ 1.04
- Sand content $\leq$ 10% by weight.

The wall construction contractor performed all tests and furnished and maintained all the testing equipment needed to verify compliance of the slurry with the standards listed above.

The slurry mixture was prepared in a pit southeast of the site in the support area (see Figure 10). The dimensions of the slurry mixing pit were 50 feet x 110 feet x 10 feet (15 m x 34 m x 3 m). The slurry was continuously mixed and tested to assure that specifications were met. Slurry was pumped from the pit into the open sections of the trench, and to the pit where the final mixing of the backfill material was conducted.

The backfill material consisted of a mixture of native soil from required excavations, and locally imported clay soil and water. Preparation of the backfill mixture took place in two locations and in two phases. The process began on a concrete pad where the dry bentonite and soil were mixed together by a farm tractor with a high speed disc. The percentage of bentonite in the backfill mixture was 2 percent as required by construction specifications. The dimensions of the pad were 60 feet by 40 feet (18 m x 12 m). The dry mixture was then transported to a reinforced concrete pit (60 feet by 20 feet by 10 feet deep; 18 m x 6 m x 3 m) where the final mixing of the dry mixture and the slurry took place. A front-end loader was used to transport ingredient material to the pit and agitate the mixture.

Backfilling initially began when the trench was excavated about 350 linear feet (107 m). Two methods of introducing the backfill to the trench were used, pumping through a line to the trench with a concrete pump, or rear dumping into the trench by a truck. The latter method was used only during operations at the north end of the site, in Quadrants 2, 3, and 4 where distance from the backfill pit became less efficient for pumping backfill. The total quantity of bentonite used for the job was 695 bags or 1042.5 tons (946 metric tons). This quantity includes bentonite used for both the backfill and slurry mixtures. The imported clay fines used in the mixture amounted to a total of 1,872 cubic yards (1431 m^3). The amount of on-site soil used is unknown. In conclusion, the total amount of backfill used for wall construction was approximately 12,000 cubic yards (9175 m^3).

One of the potential difficulties in using the slurry trench method at the Lipari site was the exposure and handling of contaminated materials during trench excavation. Potential for air pollution, as contaminated soil was brought to the surface, was a major concern and required constant air monitoring. Air monitoring results, however, did not show toxic vapors during trenching activities. The slurry in the trench retarded vapor releases such that airborne contaminants were not detected (Ward 1984).

One problem that arose during the course of construction involved working around monitoring wells that were inside the wall. To maneuver the large construction equipment around these wells required a careful technique. However, in several instances, wells were damaged and later had to be redrilled or repaired. In anticipation of this problem during the design of the groundwater monitoring program, one of EPA's consultants proposed to install the outside wall wells first and then, as sections of the wall were completed, install the inside wells. This proposal, however, was not accepted because (1) preconstruction baseline data was desired from the inside wells, and (2) there would have been contractual problems because of the number of contractors that would have been working onsite at the same time.

Concurrent with trench excavation and backfilling activities, the area inside the wall was being graded and prepared for cap emplacement. As sections of the site work were completed, sheets of synthetic cap material were laid down and sealed together, and pipes and vents for the gas venting system were installed below the cap.

Construction activities ran 5 to 6 days per week, 10 hours per day, and continued without delays. On December 7, 1983, two months after the start date, the cutoff wall was complete. At this point, about 70 percent of the surface area inside the wall was covered with the cap and 18 inches (46 cm) of soil overburden. Operations were halted at this time, to be completed during the following spring season. Measures taken to control erosion of the wall's top surface during the winter months included the temporarily mounding the soil-bentonite over the wall as a cover, and installing aluminum irrigation pipes that drained the diked area of collected water. Operations at the site resumed on March 23, 1984. Activities to be completed at this time included the completion of cap placement, cap sheet welding, soil cover emplacement, drain and vent system installation, and final revegetation of the site area.

Synthetic Membrane Cap

The cap material selected as most suitable for the site consisted of 40-mil thick HDPE unsupported synthetic membrane material. The cover was transported to the site

300.70(b)(1)(ii)
(A)
surface seal

in rolls that were about 600 feet long by 33 feet (183 m x 10 m) wide. In total, 36 rolls or about 1,200,000 square feet (1858 m^2) of cap material were used to cover the 16-acre (6.5-ha) area.

300.70(b)(1)(ii)
(C)
grading

During wall construction, grading activities were ongoing in the area inside the wall perimeter. The land surface was reworked to create swales or natural earth gullies that crossed the site in various directions. The purpose of the final surface configuration was to direct surface runoff off the site once the cap was in place. Sheets of HDPE were then placed over the site as sections of the wall and grading were completed.

The HDPE membrane strips were initially sandbagged to keep them in place and then sealed to form one continuous cover. The strips were overlapped at least four inches (10 cm) and then welded together and the seals tested. In locations where the membrane was penetrated, such as around monitoring wells and gas venting pipes, fabricated boots were used as seals.

Before emplacement of the HDPE membrane over the top of the wall, a geotextile material was placed over the wall itself for additional structural support. The ground surface across the 16-acre (6.5-ha) site had to be graded to between two and four percent except in the landfill area. The sides of the landfill mound were compacted with noncontaminated fill to provide a surface with less than a 3 to 1 slope.

Membrane liner sealing operations were discontinued when cold weather conditions overcame the area. Obtaining a good seal is not possible when temperatures are lower than 50°F (10°C) or in conditions where the humidity is greater than 80 percent. Because of these circumstances, 30 percent of the site was left uncovered during the winter months. Uncovered areas included Quadrant 4 and the roadway or "racetrack" that ran around the inside of the wall perimeter.

Following cap emplacement and welding operations, an earth cover, consisting of more than 30,000 cubic yards (22,940 m^3), which were removed during grading activities and stockpiled, was placed over the cap. The average thickness of the soil overburden cover is 18 inches (46 cm). Six inches (15 cm) of top soil was then placed on top of the overburden, providing a media for plant growth, which in turn protects the membrane cover from erosion and creates a more aesthetically pleasing area.

In March 1984, when construction activities were resumed at the site, the observation was made that despite the erosion controls that had been constructed (e.g., mounding and irrigation pipes), erosion had occurred along the northwest, northeast, and southeast sideslopes outside the wall perimeter. Eroded material was replaced and the affected areas were patched. Concurrently, the cap was being completed in Quadrant 4 and along the "racetrack." During the second phase of cap emplacement, there were several incidents in which the membrane cap ripped and had to be repaired. The repairs made were then tested and inspected to ensure good integtrity.

Permanent surface runoff and erosion control techniques were implemented during this phase of activity. Plastic (4-inch, 10-cm PVC) subdrains have been placed within the earthen swales that run across the site. Installation of the drains between the synthetic cap and the soil overburden were accomplished by first removing the overburden within the swales, laying down the drain pipe, and then recovering the swales. These drains direct water that has infiltrated the soil overburden away from the site. Four concrete surface samples were also constructed to direct surface water offsite. Three of the drains are 110 feet long, 10 feet wide, and 4 inches thick (34 m x 3 m x 10 cm). The fourth drain is 60 feet long, 10 feet wide, and 4 inches thick (18 m x 3 m x 10 cm), and plays a comparatively minor role in directing sheet flow across the top of the wall. All four drains have gentle slopes of less than one percent (Figure 11).

300.70(b)(ii)(D)
(2)
drainage ditches

On May 15, 1984, the installation of the cap was completed. The application of 6 inches (15 cm) of topsoil over the soil cover and the hydroseeding of the area were the final phases of the operation. However, before these activities were completed, groundwater levels within the confines of the wall had risen such that in Quadrant 4 water was approaching the top of the wall and was affecting subgrade support of the liner (Figure 11). The reasons why water levels were so high are unknown at this time. The EPA, NJDEP, and ACE believe that the combination of heavy rains that occurred between October 1983 and May 1984 (50 percent higher than the annual average rainfall during this time), and the fact that the site was not completely covered during this time, caused the water levels to rise to the degree that they did. It was decided by EPA, NJDEP, and ACE to initiate a short-term pumping program to lower the water levels to enable cap repairs to be completed (see following subsections for details).

300.70(b)(1)(ii)
(D)
revegetation

Gas Vent System

The gas venting system at the site was completely installed by October 11, 1983. The system consists of two underground, 4-inch (10-cm) perforated PVC pipes that run in a northeast-southwest direction across the landfilled area in Quadrant 1, and five vent risers (see Figure 11). The two PVC pipes are parallel to one another, with approximately 200 feet (61 m) between them. They were installed prior to cap emplacement during the period of wall construction and lie about 3 feet (0.9 m) beneath the finished grade. The pipe located farthest to the west is about 300 feet (91 m) long and is connected to two vent risers. The second pipe, located about 200 feet (61 m) to the east, is approximately 500 feet (152 m) long and is connected to three vent risers. The vent risers are connected to the buried manifold pipes and consist of open pipe installed perpendicular to the underground pipes and the ground surface. Filters are not attached to the riser exit points.

Groundwater Collection and Treatment System

Long-Term Program--

The long-term collection and treatment of contaminated groundwater at the Lipari Landfill, described as Phase II of the overall remedial program, has not yet been implemented at the site. A bench-scale treatability study, which was conducted under the direction of EPA to assess the potential impacts of the water at the Gloucester County Utilities Authorities (GCUA) Wastewater Treatment Plant, addressed the following concerns expressed by the GCUA:

300.70(b)(2)(ii)
(C)
groundwater
pumping
300.70(b)(2)(ii)
(A)(1)
conventional
wastewater
treatment

- Contaminants in the Lipari leachate may inhibit the biological treatment process.
- Contaminants in the groundwater may pass through the system untreated and thereby be present in their effluent.
- Contaminants may accumulate in the sludge.
- Potential problems with air emissions at pump stations.
- Potential damage or degradation of sewer lines caused by groundwater contaminants.

The study, which ran for 9 weeks, consisted of two bench-scale activated sludge reactors that were fed a

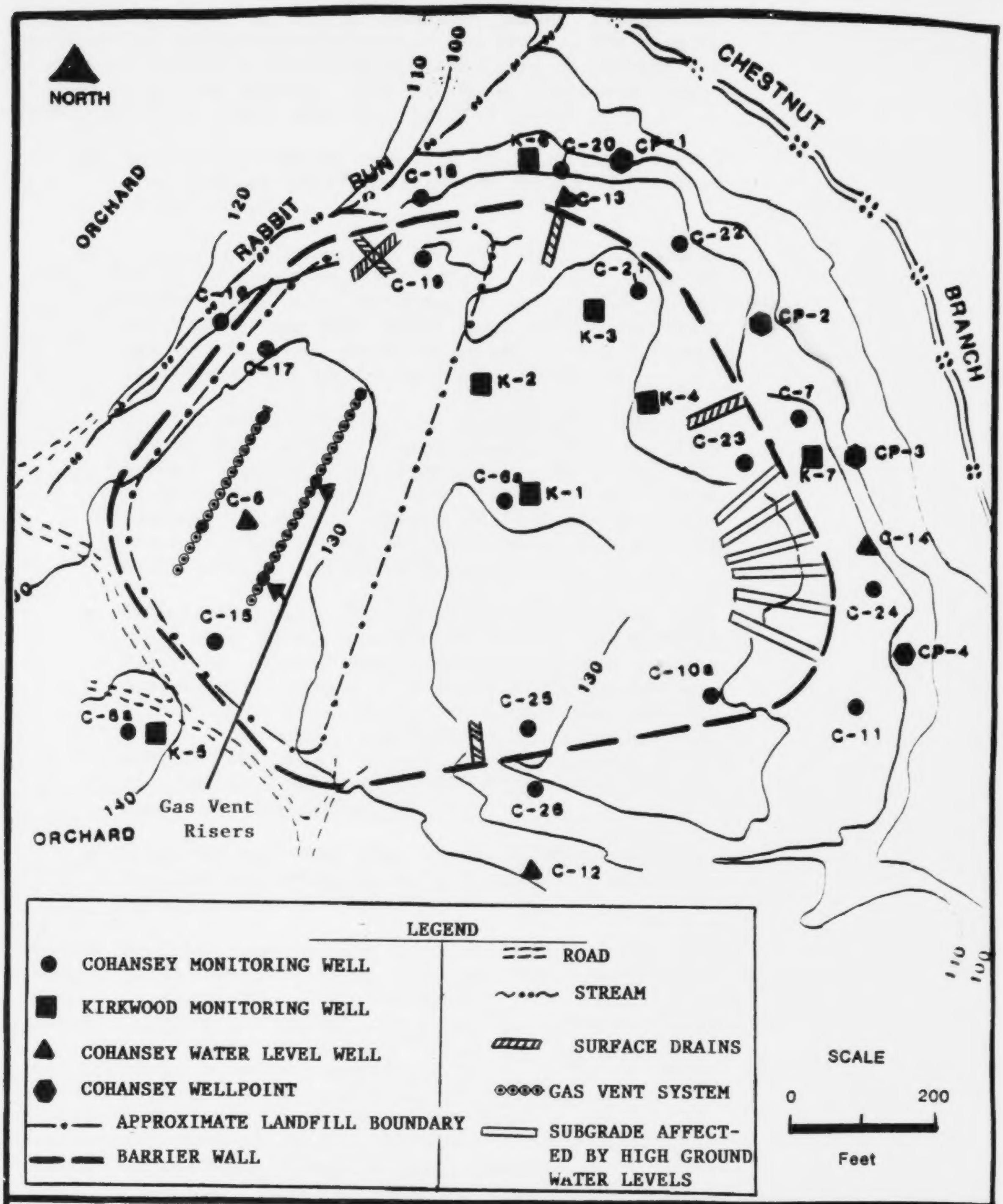


Figure 11. Approximate Locations of the Gas Venting System and Concrete Drains at the Lipari Landfill, NJ

Source: USACE 1984

mixture of synthetic sewage and Lipari leachate. Major upset conditions were not observed during either the acclimation or operation phases of the study. The reactor ran under generally steady-state conditions throughout the 6-week operation period. The following conclusions were made regarding GCUA's specific concerns listed above:

- Inhibitory effects regarding the biological treatment process were not observed during the course of the study.

- Treatment efficiencies for the organic compounds were as expected (> 60%). Metals removal efficiencies were as expected or greater except for copper and zinc which were widely scattered and inconsistent, possibly caused by low influent levels relative to the detection limit.

- Average concentrations of contaminants found in sludge from Reactor 1 were between 39.5 and 47.9 mg/kg. Sludge from Reactor 2, where influent concentrations were five times greater than Reactor 1, rarely showed the contaminant compounds. There was no difference in operating conditions to explain this anomaly.

- Calculations made to determine the minimum pump seal leak rate, needed to develop potentially hazardous ambient concentrations of the various contaminants, ranged from 33 to 3,000 gallons per minute (2 to 189 l/sec). The conclusion is that there is a small possibility of encountering ambient levels of organic compounds near NIOSH Time Weighted Averages (TWAs) if the pump seals at a pump station failed.

- Potential for sewer line damage caused by degradation by contamination is low based on corrosive chemistries and dilution factors.

Despite positive results from the treatability study, the GCUA is still hesitant about accepting the Lipari water without pretreatment. At the minimum, the water will probably require pretreatment to reduce its naturally high iron concentrations which could have negative effects on the treatment plant's operations. The GCUA is still concerned about the accumulation of contaminants in the sludge. The 1983 study only addressed a few of the contaminants present in the leachate in its sludge study phase. In addition, there is still concern about emissions of volatile organics escaping from manholes near homes. The POTW has requested that further studies be conducted addressing these specific concerns. Consequently, the long-term groundwater treatment program is still being evaluated. A feasibility study is currently being conducted. Results from this study will not be available until the fall of 1985. Potential off-site impacts of the site are also being evaluated in the current study.

Short-Term Program--

In response to the high groundwater levels within the confines of the wall, a two-month pumping program was initiated on September 5, 1984. Well points were installed in Quadrant 4 through which water was pumped at a rate ranging between 30 and 125 gpm (114 and 473 l/min). In October 1984, the pumping scheme was augmented to include two large diameter, deep production wells to increase the rate of discharge. The objective was to lower the water level by approximately four feet (1.2 m). The decision was made to send the leachate to GCUA after it s pretreated onsite using mobile sand and carbon units. Pumping was completed on October 22, 1984, and the final on-site work was completed on November 16, 1984.

300.70(b)(2)(ii)
(C)(2)
direct waste
treatment
methods - carbon
adsorption

COST AND FUNDING

Source of Funding

The EPA Region II Emergency Response and Hazardous Materials Inspection Branch paid for the construction of the 8-foot (2.4-m) high chain link fence around the site. Through the State Superfund Contract (SSC), the State of New Jersey assumed responsibility for costs of maintenance of the site after construction was completed, cost of interests in the land, and 10 percent of the costs of construction of the containment system (i.e., slurry wall, synthetic cap, and associated items). EPA paid 90 percent of the cost of construction of the containment system as agreed in the SSC. EPA also paid for all of the preparation of design documents, specifications, health and safety plan, construction documents, and cost estimates. The costs of the feasibility study for evaluating groundwater treatment alternatives and a long-term groundwater monitoring program were both paid by EPA's Office of Research and Development.

Prior to the enactment of Superfund in 1980, available mechanisms of funding for activities such as surveillance, analysis, and monitoring of the site included Clean

Water Act Section 311 funds; Section 208 funds for research and development, the CWA and the New Jersey Spill Compensation Fund; and a revolving trust (N.J.S.A. 58:10-23.11 et seq). EPA expended $220,000 of Section 311 funds and $50,000 of R&D monies by August 1981.

Selection of Contractors

More than 20 contractors and subcontractors participated in various activities at the Lipari Landfill. Because the site involved county, State, and Federal agencies to varying degrees at various times, selection and participation of contractors depended on selection criteria and/or previously let contracts pertinent to the agency responsible for a particular task. The most prominent contractors, the nature of their involvement, and the client agencies are summarized in Table 10.

Prior to EPA involvement with the site, testing and analysis of water and sediment samples were conducted, along with bioassays, on the nearby Alcyon Lake by Rossnagel & Associates, who were under contract to Gloucester County from September 1973 to June 1979. Their subcontractor, Site Engineers, Inc., executed a subsurface investigation with permeability testing at the landfill. Reports from both firms were submitted in the fall of 1979. Rossnagel & Associates was selected for their professional services contract based on their former work for the Borough of Pitman and their familiarity with the site. Site Engineers, Inc., was selected due to its technical capabilities and its proximity to the site. Parties which were potentially liable for cleanup of the site also chose contractors for studies. Betz, Converse and Murdoch of Plymouth Meeting, Pennsylvania, was chosen by a responsible party for two tasks: to evaluate some of the work that EPA had done and to prepare an engineering study. The first task, completed January 25, 1982, was requested so that the responsible party could have a competent, independent evaluation of the activities progressing at the landfill. The preliminary engineering study was undertaken to assess the situation at the landfill and propose a strategy for mitigation of the leachate flow using low-risk, passive technology. For this task GeoTrans, Inc., of Reston, Virginia, was used as a subcontractor to produce a preliminary conceptual design based on numerical modeling of groundwater flow at the site. Both firms were selected on the basis of their good reputations, with technical capabilities being the prime criterion. The contractors produced their studies in a very short time, spending 3 weeks on the evaluation of the cleanup program, about 3 months on the preliminary engineering study, and about 2 weeks on the numerical

TABLE 10. CONTRACTORS AND SUBCONTRACTORS

Contractor/Subcontractor	Agency/Party	Task
Rossnagle & Associates^P	Gloucester County	Sampling and analysis
Site Engineers	"	Subsurface investigation
Betz, Converse & Murdoch^P	Rohm & Hass	Evaluation, engineering study
GeoTrans, Inc.	"	Modeling groundwater
Roy F. Weston, Inc.^{P}	"	Sampling
R.E. Wright Associates^P	U.S. EPA, Region II	Remedial study
Lawler, Matusky & Skeller	"	Leachate characterization
Ecology & Environment^P	U.S. EPA, Headquarters	TAT, FIT contracts
Fred C. Hart Associates	"	Field investigation
Woodward-Clyde Consultants	U.S. EPA, Office of Research and Development	Research manual, stabilization, well installation & groundwater & soil sampling; geophysical testing
Energy Resources Company	"	Groundwater chemistry
CH2M Hill/Camp, Dresser & McKee, Inc.	U.S. EPA, Headquarters	REM Contract, predesign, cost & construction schedule, specifications for construction
Radian Corporation^P	U.S. EPA, Office of Research and Development	Environmental assessment & cost-effectiveness, leachate treatability study
JRB Associates^P	U.S. EPA, Office of Research and Development	Groundwater monitoring
New England Pollution Control Co.	U.S. EPA Emergency Response and Hazardous Materials Inspection Branch (Region II)	Security fencing
D'Appolonia Waste Management Services, Inc.^{P}/IT Corp.	U.S. Army Corps of Engineers	Construction of remedial action
Schlegel Lining Technology, Inc.	"	Synthetic cap

P = prime contractor

modeling of the flow of groundwater. It should be noted that Betz, Converse and Murdoch previously worked for the New Jersey Division of Solid Waste Administration in January of 1979 on a small contract for sample analysis of Lipari site leachate. Roy F. Weston, Inc., of West Chester, Pennsylvania, did some sampling work for the responsible party in the late 1970s. They were selected on the basis of past experience with the responsible party.

Starting in early 1980, EPA Region II funded a remedial investigation/feasibility study which was conducted by R.E. Wright Associates, Inc. (REWAI). Funds were made available under Section 311 of the Clean Water Act and hence REWAI was responsible to the Commander of the U.S. Coast Guard, Third District, who acted as contracting officer for the study. Information on the character and treatability of the leachate was provided by Lawler, Matusky & Skiller of Pearl River, New York, under subcontract to REWAI. Contractor and subcontractor were selected on a basis of competitive bids, after each bidder's capability to do the work had been established.

In March of 1981, R.E. Wright Associates, Inc., working in conjunction with the Technical Assistance Team (TAT), Ecology and Environment, Inc., of Cheektowaga, New York, drilled 18 monitoring wells at the site. Fred C. Hart Associates, a subcontractor to Ecology & Environment's Field Investigation Team (FIT), assisted in the emplacement of the wells. Fred C. Hart Associates also sampled surface water and soil, and conducted an air survey using an OVA and carbon tubes.

Woodward-Clyde Consultants, Inc., were selected by the Solid and Hazardous Waste Research Division (SHWRD) of the U.S. EPA's Municipal Environmental Research Laboratory in Cincinnati, Ohio, to produce a manual on methods and technologies for mitigation and control of hazardous waste sites, using the Lipari site as a textbook example. To reflect the needs of the SHWRD, the focus of the contract was modified in 1982 towards stabilization of the hazardous waste by physical-chemical methods (i.e., solidification of organic waste sludges). With the shift in the status of their research, Woodward-Clyde Consultants obtained soil and groundwater samples from monitoring stations in March 1981. Under subcontract to Woodward-Clyde Consultants, Energy Resources Company, Inc., completed analytical testing of the groundwater in August 1981.

With apparently anomalous results from the lower Kirkwood wells and a potential problem of leakage caused by drilling techniques employed, additional field studies and groundwater analyses were requested of Woodward-Clyde by the U.S. EPA, and WCC installed four additional deep wells into the lower Kirkwood formation.

For EPA Region II, Ecology and Environment had both the FIT and TAT contracts for 2 years with 6-month extensions on each, beginning in early 1980. In mid-1982, the REM Contract was obtained by Camp, Dresser and McKee, Inc. (lead), along with approved subcontractor CH2M Hill (among others). The REM I selection process used the "Brookes Act Procedures for Selection of Architectural and Engineering Firms" to determine engineering experience and capabilities.

Camp, Dresser & McKee were required under their REM contract to evaluate the Radian report on cost-effectiveness of the remedial action (see below), as well as other reports. CH2M Hill, with Camp, Dresser & McKee, provided a predesign report (October 19, 1982), a cost and construction schedule (March 10, 1983), and draft specifications and drawings for construction (March 24, 1983). Both firms were responsible to EPA.

To fulfill the requirements of the National Environmental Policy Act, environmental assessment and cost-effectiveness documents were prepared by Radian Corporation under a direct procurement contract to the U.S. EPA. On January 12, 1983, Radian completed the effort to develop a monitoring program to evaluate the effect of remedial actions in Alcyon Lake for the Municipal Environmental Research Laboratory in Cincinnati, Ohio. Also in 1983, they reported on the treatability of the contaminated groundwater, using a bench-scale model and a synthetic sewage to determine the effects of the contaminated groundwater, on the local wastewater treatment works.

Prior to both of these tasks, Radian assessed the cost-effectiveness of 32 remedial action alternatives (completed July 16, 1982) for the Hazard Remediation Section of EPA Region II.

Fencing of the site was accomplished by New England Pollution Control Company under contract to the EPA Region II Emergency Response and Hazardous Materials Inspection Branch. A competitive bid process was used for selection of the contractor.

The U.S. Army Corp of Engineers, Kansas City District, acted as reviewer of construction bids to determine the low responsive bidder for construction of the remedial action at the site. Of the 10 responsive bidders, D'Appolonia Waste Management Services, Inc., of Pittsburgh, Pennsylvania, was selected for construction activities. These construction activities ranged from clearing and grubbing to final grading and hydroseeding. (In early 1984, D'Appolonia Waste Management Services, Inc., was bought by IT Corporation.) Synthetic cap emplacement was accomplished by Schlegel Lining Technology, Inc., of Woodlands, Texas. Schlegel was chosen as subcontractor because it could manufacture, install, and inspect its product, and guaranteed its work and product. Schlegel HDPE sheeting exceeded the technical specifications required for the project.

Additional monitoring activities were undertaken by JRB Associates under a previously let, 3-year contract to EPA's Office of Research and Development. With the assistance of its subcontractor, A.C. Schultes, 19 new wells were drilled and are presently being used in a long-term monitoring program.

Other subcontractors and the work they performed for the site include Quinn & Associates for aerial mapping and topographical maps, Epic Photography for site photographic work, Empire Soils and A.C. Shultes for drilling, and West Coast Technical Services for chemical analysis. No selection information is available on these subcontractors.

Project Cost

Since the writing of this report, more comprehensive data regarding actual costs incurred at the Lipari site have been compiled by EPA, and although these data are not included here, they are available.

The cost data for the Lipari site was provided at the time of this writing, almost entirely in the form of estimates. In all cases where estimates changed with time, latest estimates were used. Estimates were derived from reports, bidding documents and bids, and available contracts. The source of lump-sum bids for construction activities was the "Abstract of Bids-Construction" issued by the U.S. Army Engineer District, Kansas City. Information on the unit costs of safety equipment was derived from JRB Associates report, "Health and Safety Costs Associated with Well Drilling Program, Lipari Landfill." Other sources of estimates for activities conducted at the Lipari site include the Construction Cost Estimate produced by the Army Corps of Engineers, CH2M Hill's "Cost by Task" of pre-remedial action activities, and the "Estimated Cost and Construction Schedule for Lipari Landfill Leachate Containment System" by CH2M Hill.

Since at the time of this writing (July 1984) remedial action at the site had not been completed, invoices and total costs were not available. In addition, estimates were not available in some instances where certain tasks or subtasks were accomplished under previous contracts.

Preconstruction---

Project labor costs for design work done by CH2M Hill and Camp, Dresser & McKee, Inc., are summarized in Table 11.

Project funding was exhausted by April 1983 with 95 percent of the project complete. As a result, CH2M Hill submitted a request for authorization of an additional $8,680 to complete the project. The major contributing factor to the cost overrun was reported to be a delay in schedule, caused in part by a delay in project authorization and in part by the amount of time needed for review of drafts.

Removal Action---

A removal action, separate from site remedial activities, consisted of securing the site with fencing. Associated cost estimates are listed in Table 12. After installation of the security fence, additional fence had to be added and some of the already emplaced fence needed to be moved. The additional cost of this fencing and adjustment was estimated at $21,900; it is colisted with other construction costs, however, which are detailed in the next subsection.

Remedial Activities---

The cost of remedial activities at the Lipari site is the sum of the costs of the following components:

- Groundwater monitoring wells
- Cutoff wall
- Synthetic membrane cap
- Passive gas collection/venting system.

Significant health and safety costs were encountered in each component and are delineated where the information was available (see Table 16 and the associated text for more information). Other construction components contributing to the cost of remedial activities include project startup, site preparation, clearing, grubbing, stripping, earthwork, underdrain, finish grading, revegetation, and project closeout. A groundwater collection and treatment system may be implemented; cost information on this item

TABLE 11. DESIGN COST ESTIMATES

Work Plan	11,329.42
Collect & evaluate existing data	16,103.50
Predesign report development	40,400.83
Assessment of existing wells	1,037.82
Determination of permitting requirements	1,343.03
Predesign report	6,690.07
Assess work for marsh area	5,890.43
Health & safety plan	6,844.31
Drawings & technical specification	28,193.56
Contract document	12,525.34
Construction cost estimate & schedule	5,783.44
Profit, subcontractor	11,572.90
Subtotal subcontractor cost	147,724.67*
Prime oversite	4,719.74
Profit, prime	12,959.30
Total estimated cost and profit	165,421.71*

Source: CH2M Hill 1982a

*Two errors in the addition of cost estimate information resulted in overpricing by $10.02 and $18.00, respectively.

TABLE 12. REMOVAL ACTION: SECURITY FENCING ESTIMATE

Item	Quantity	Unit Price	Cost
Security fence with climbing deterent	3438' x 8'	36.93/foot	$126,963.00
Floodplain fence	2300' x 6'	18.49/foot	$ 42,530.00
Surveying & deliverable plot plans			$ 5,520.00
Total cost			$187,533.00

Source: USEPA 1982a

is presently unavailable. Costs of components from the accepted construction bid submitted by D'Appolonia can be found in Table 13. At the time of this writing, invoices were not available to delineate actual costs incurred.

Before construction could begin, it was necessary to acquire an easement for construction. The temporary construction easement cost was $5,000, of which $1,000 was paid as an appraisal of easement cost.

A health and safety plan was implemented to ensure protection of all personnel associated with the remedial action. The lump sum estimate of cost given by the selected construction bidder was $140,000. Information from the one available estimate which details unit costs is given in Table 14.

Mobilization, temporary construction facilities, and utilities were estimated at between $96,000 and $287,500. The lump sum estimate given by the successful construction bidder was $130,000.

The cost of relocating the fence was estimated at $11,200, and additional fence required for the project was estimated at $10,700. The actual amount of additional

TABLE 13. CONSTRUCTION BID ESTIMATES FOR LIPARI LANDFILL

Item	Bidder's* Estimate (thousand dollars)
Project Startup, Site Preparation and Site Service	130
Safety and Health	140
Site Security	69
Clearing, Grubbing, and Stripping	59
Disposition of Existing Monitoring Wells	51
Miscellaneous Site Work	80
Soil-Bentonite Cutoff Wall	740
Earthwork and Synthetic Membrane Cap	660
Underdrain and Gas Venting Systems	50
Finish Grading and Grass	114
Project Closeout	51
Total	2,144

*D'Appolonia, presently part of IT Corporation, IFB No. DACW 41-83-B-0183

Source: D'Appolonia Waste Management Services, Inc. 1983a.

TABLE 14. SAFETY EQUIPMENT UNIT COSTS

Item	Unit Price
Non-Expendables	
• Wilson Full Face Airline Respirator	$191.75
• Wilson Full Face Cartridge Respirator	85.00
• Scott Air Pack	925.00
• Scott Air Pack Spare Bottle	225.00
Expendables	
• Emergency Eye Wash Station	$ 14.50
• Granet Nitrile Gloves	1.67
• Rainfair PVC Steel Tip Boots	16.00
• Wilson Respirator Cartridges (AG/OV)	2.50
• Wilson Respirator Cartridges (OV)	2.67
• Kappler Coveralls	3.00
• Apex First Aid Kid	62.00
• Alconox Soap	30.00
Leased Equipment	
• 2400 psi Bottles	$25/bottle/wk
• 3/8" Hose	1/foot/wk
• Air Bottle Refills	15/bottle
• High Pressure Washer; Decontamination	154/wk
• Cargo Van	135/wk 0.18/mile
• Health Exams	$300 - 320/ individual

Source: JRB Associates 1983b

fence required and related costs were not quantified and are included under the bid item labeled "Miscellaneous Work."

Disposition of Existing Wells and Groundwater Monitoring---

Included in some of the estimates for groundwater monitoring wells is the cost of assessment and disposition of old, damaged, or unusable wells. Bid estimates for the disposition of existing wells ranged from $41,000 to $85,000. The lowest estimate was an early estimate for simply plugging and capping the 11 wells; other estimates included assessments of wells, permits, self-contained breathing apparatus and other safety equipment, decontamination equipment, physical exams, and other related costs.

Estimates from the U.S. Army Corps of Engineers listed the cost of plugging abandoned wells and protecting existing wells at $500 each. With 11 wells to be plugged this was the lowest estimate, but it included nothing more than the sealing of these wells. The bidder selected for construction activities estimated that the cost of disposition of the existing wells would be $51,000. No details or itemization of costs were available because this was a lump-sum bid.

Neither report requirements nor safety equipment were included in the cost of evaluation of existing wells.

A cost estimate breakdown presented by JRB Associates for additional monitoring wells is shown in Table 15. Labor costs include labor by project geologists/engineers and labor overhead, and account for 29 percent of the total cost. Of the total $17,967 estimated, 45 percent was designated for subcontracts covering the drilling of six 3-inch (7.6-cm) diameter wells to an average depth of 25 feet (7.6 m). Detailed itemized information on the cost of well components was not available, but the subcontractors would be responsible for mobilization and demobilization; safety procedures; installation of casing, screen, sandpack, and seal; well development and drilling; pipe (3-inch; 7.6-cm PVC; six wells; 15 ft/well; 4.5 m/well); screen (3-inch; 7.6-cm, 10 ft/well; 3m/well); covers (6-inch; 15-cm locking-type); and bentonite cement. Safety equipment included the rental and servicing of air tanks for six people. Note that these estimates did not cover documentation costs.

TABLE 15. ESTIMATED COST OF SIX ADDITIONAL MONITORING WELLS

	Estimated Cost
Labor (160 hours total)	$ 2,368
Labor Overhead	$ 2,771
Subcontracts for Drilling	$ 8,000
Safety Equipment ($710/week)	$ 710
Organic Vapor Analyzer (6 days per $50/day)	$ 300
Consumables	$ 400
Travel	$ 300
G&A Expenses	$ 2,227
Fixed Fee	$ 891
Total	$17,967

Source: JRB Associates 1983b

Information from another, more detailed estimate for groundwater monitoring wells at the Lipari site is presented in Table 16. Of the 19 new monitoring wells installed, 12 were 4-inch (10-cm) diameter, shallow wells (average depth, 35 feet, (11 m); 3 were 8-inch (20-cm) diameter, deep wells (average depth, 65 feet, (20 m); 4 were 2-inch (5-cm) diameter wellpoints (average depth, 15 feet, (4-6 m). Because of the dissimilarity of the wells and a paucity of information, costs-per-well or costs-per-foot drilled cannot be determined.

Cutoff Wall---

The estimates for approximately 116,313 feet^2 (10,806 m^2) of soil-bentonite cutoff wall ranged from $500,000 to $837,000. Generally, estimates were based on a cost of around $6.00 per square foot, with some variations arising from the source of borrow material used for admixture with the bentonite. Whether the potential for excavation of contaminated soil and the related increase in costs were taken into account in these estimates is not clear. Construction specifications which affected cost of the wall included a permeability of not less than 3.2 x 10^{-9} ft/sec (1 x 10^{-7} cm/sec) for a wall not less than 30 inches (76 cm) wide. The depth of wall varied from 30 to 52 feet (9 to 16 m) depending on the depth of soil to the clay aquitard to which the wall was keyed. A long-arm backhoe was necessary for excavation purposes.

TABLE 16. ESTIMATED DRILLING COST FOR LIPARI WASTE DISPOSAL SITE, INCLUDING NECESSARY HEALTH AND SAFETY REQUIREMENT AND EQUIPMENT

Item Number and Description	Unit Price	Estimated Quantity	Total
1. Mobilization and Demobilization Truck Rig and Crew	$950.00/ea	2	$1,900.00
2. Earth Drilling, w/6" I.D. Hollow Stem Augers, Including SPT Samples			
A. Above Groundwater Table	19.00/LF	225/LF	4,275.00
B. Below Groundwater Table	39.00/LF	315/LF	12,285.00
3. Earth Drilling, 6" - 8" Diameter, Below Bottom of 8" Casing, Including SPT Samples	39.00/LF	89/LF	3,471.00
4. Stainless Steel Screen, 4" Diameter, 10 slot/inch	54.00/LF	150/LF	8,100.00
5. Steel Riser and Sump Pipe	8.00/LF	480/LF	3,840.00
6. Installation of Monitoring Wells, Paid by Length of Sump, Screen and Riser Pipe	16.00/LF	630/LF	10,080.00
7. Protective Casings, 6" Diameter x 60" Length, w/ Locking Caps	140.00/ea	12	1,680.00
8. 8" Diameter Casing, Grouted in Place, with Locking Cap	40.00/LF	110	4,400.00
9. Decontamination Time	100.00/hr.	39	3,900.00
10. Development Time	100.00/hr.	30	3,000.00
11. N.J. DEP Well Permits	10.00/ea.	19	190.00
12. Health & Physical Exams	320.00/ea.	4	1,280.00
13. Self-Contained Breathing Equipment	104.00/day	20	2,080.00
Estimated Total			$60,481.00

Source: JRB Associates 1983b

Synthetic Membrane Cap---

The government estimate for the emplacement of the synthetic membrane cap, prepared by the Army Corps of Engineers, included the covering of 74,500 square yards (62,700 m^2) with a membrane costing $4.00/square yard, for a total of $298,000. However, the size of the site to be covered was 16.7 acres (6.76 ha) equivalent to 80,828 square yards (67,582 m^2), an increase of about 8 percent. Further, the costs of the high-density polyethylene sheeting and its emplacement were reportedly higher. Earthwork and synthetic membrane cap were bid together at an estimate of $660,000 by the prime contractor for construction. Other estimates on the synthetic membrane cap are listed in Table 17.

Underdrain and Gas Venting---

Bid estimates for an underdrain and gas venting system ranged from $10,000 to $50,000. The approved bidder's estimate was $50,000. The estimate given by CH2M Hill was $6,700, based on costs of 3295 feet (1004 m) of pipe at $1.80 per linear foot ($5.91/m) and 5 gas vents at $165 each. This estimate appears to cover only materials.

PERFORMANCE EVALUATION

The remedial response at the Lipari Landfill has not yet been completed. Further additional remedial action may be forthcoming depending on the outcome of studies examining the adequacy of the present remedial response. Therefore, only a partial evaluation of the effectiveness of remedial measures implemented at the site is given here at this time. In addition, the following section highlights some important successes and problems involved with the program's implementation thus far, in hope that knowledge gained through these accounts will benefit the implementation of future remedial response programs at other sites.

Evaluation of the performance of the waste containment system is somewhat impaired by the lack of well-defined objectives for the system. Remedial actions were to "prevent or minimize the continued generation of leachate" and "control further contaminant migration off-site" in a timely and cost-effective manner. These objectives do not contain terms of quantification; hence, any effective remedial action in some ways would meet these goals. For these reasons the evaluation is limited to examining the effectiveness of the remedial actions from observations of documented evidence and cannot be based on comparisons to precalculated values.

TABLE 17. SYNTHETIC MEMBRANE CAP AND RELATED COSTS

Item	Source*	Total Cost
Grubbing, Clearing, and Stripping	1	$34,400
Grubbing, Clearing, and Stripping	2	59,000
Above with Hydroseeding	3	184,150
Earthwork	4	185,000
Earthwork	1	205,900
Cut-off Wall	2	740,000
Underdrain and Gas Venting	1	6,700
	2	50,000
Imported Fill	4	200,000
Synthetic Membrane Cap	4	470,000
Synthetic Membrane Cap	1	298,000
Above w/Earthwork	2	660,000
Grading and Seeding	1	190,600
Grading and Seeding	2	114,000
Grading and Seeding	4	290,000

*Sources:
1. CH2M Hill 1983c
2. D'Appolonia Waste Management Services, Inc., 1983a
3. U.S. EPA 1982b
4. CH2M Hill 1983a.

Site Security

Ultimately, the security measures taken at the Lipari Landfill site effectively segregated the contaminated areas from the surrounding population. The posting of warning signs in the area was the initial technique utilized to forewarn residents of potential danger. However, this technique alone was not adequate to isolate the site from the public. The later installation of a security fence around the 16-acre (6.5-ha) site was found to be the only means of completely and effectively segregating the site. There have not been any reported breaches in security at the site since the installation of the security fence.

Monitoring Well Installation

The groundwater monitoring plan for the Lipari Landfill site was designed to monitor both the overall groundwater quality in and near the site, and the effectiveness of the containment system. The design of the monitoring wells to be used for these purposes met specifications required for the successful monitoring of the landfill. However, the first wells installed at the Lipari site in 1981 (the C- and D-series) were constructed through the Cohansey aquifer and into the Kirkwood aquifer may have introduced contamination of samples. The installation of later wells was carefully supervised with no problems occurring during installation operations. Problems related to the monitoring wells developed subsequent to their design and installation. During the construction of the containment wall, some of the wells were affected by heavy construction equipment. Future remedial programs at sites may require earth moving equipment which will be used in close proximity to wells that are already in place. Preventative measures that may greatly reduce or eliminate potential damage to these wells might include identification of well heads with large, brightly colored markers and emplacement of structures around the above-ground portion of the wells. Another alternative to avoid well damage would be to complete heavy construction prior to the installation of wells. However, in a case such as the Lipari Landfill, in which the accuracy of baseline data is critical to later evaluations, this should not be an option.

Containment System

The slurry wall/cap containment system at the Lipari Landfill site was installed without delays in the schedule. There are, however, a few aspects of the construction phase that were problematic.

As a result of topographical constraints, limited easements, and cost-effectiveness issues, the slurry wall encompasses only part of the contaminated plume. Along the western portion, it was constructed so close to the landfill's western boundary that during excavation, some waste materials were visible in the trench. It is not known what exact effect the construction of the slurry wall through waste material will have on the long-term stability of the wall and its impermeability. It should be noted that during the wall's construction no loss of slurry was detected and, therefore, the degree of penetration of the wall into the disposal area was probably limited. There has been no noticeable short-term effect. In its inception, the cutoff wall at the Lipari site was designed in such a manner that flux of materials across the containment boundary was limited to a specified rate. Permeability testing of the soil-bentonite mixture of the wall showed a lower permeability than the 10^{-7} cm/sec specified, by one order of magnitude. A 30-inch (76.2-cm) slurry wall with a permeability of 10^{-7} cm/sec will reach theoretical breakthrough in about 240 years; the same thickness of wall with a permeability of 10^{-8} cm/sec will reach theoretical breakthrough in 2404 years. Theoretically, in other words, the slurry cut-off wall at the Lipari site should exist in a stable condition for the next 2404 years.

The polyethylene membrane cap that covers the top of the site has a permeability of less than 10^{-9} cm/sec. The combined use of these materials in addition to the underlying Kirkwood clay layer has effectively contained the waste material inside the boundaries of the containment system. Those wastes and contaminated groundwater plumes not within the system are unaffected by it, except insofar as the groundwater patterns around the containment system are altered.

Another aspect of the wall/cap installation that warrants discussion involves scheduling and timing of the different construction phases. At the Lipari Landfill, the installation of the cap was not completed in 1983 because of low winter temperatures, which resulted in approximately 30 percent of the enclosed area being left uncapped and open during the late winter and early spring months. One possible reason for the high groundwater levels later discovered within the wall is that the installation of the cap had not been completed and precipitation directly infiltrated the open area. This high water level problem might have been avoided if overall construction activities had been scheduled differently, such that the emplacement of the cap could have commenced earlier and been completed before temperatures became too low for welding operations to continue. Alternately, a temporary surface covering could have been used for collecting and shedding precipitation.

Groundwater Collection and Treatment

The efficacy of the wall/cap system that has been installed at the Lipari site might be enhanced with the implementation of a groundwater collection and treatment system. However, this phase of the remedial program is still undergoing evaluation by EPA and local authorities to determine whether or not the removal of groundwater from the confines of the wall will, in fact, enhance the long-term integrity and effectiveness of the containment system. At the time of this writing, the decision had not been made whether a groundwater collection/treatment system is necessary at the Lipari site.

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PICILLO FARM

COVENTRY, RHODE ISLAND

INTRODUCTION

NCP References

Picillo is a 55- acre (22-ha) former pig farm located in a rural area of Coventry, Rhode Island, approximately one mile southwest of the intersection of Route 102 (Victory Highway) and Perry Hill Road (Figure 1). A 7.5 acre - (3-ha) cleared area on a hill on the southwest corner of the property was used illegally as a hazardous waste disposal site in the late 1970s. Over 10,000 drums and an undetermined volume of bulked liquid chemicals containing wastes such as industrial solvents and soils, pesticides, PCBs, paint sludges, plasticizers, resins, explosives, filters, still bottoms, and other potentially hazardous materials were buried onsite in four trenches known as the northeast, northwest, south and west trenches. Leachate from the trench areas migrated through the soil into a nearby swamp, contaminating the groundwater, surface water, and soil within the vicinity. Additionally, air monitoring near the swamp showed contamination due to volatile organic compounds from the swamp. A response, initially State-led, began in 1980 and at the time of this writing was ongoing under the direction of U.S. EPA Region I. The four trenches were excavated and their contents were disposed of in secure off-site disposal facilities; however, a decision regarding further cleanup measures would not be made until after a second and final feasibility study was completed in November 1984.

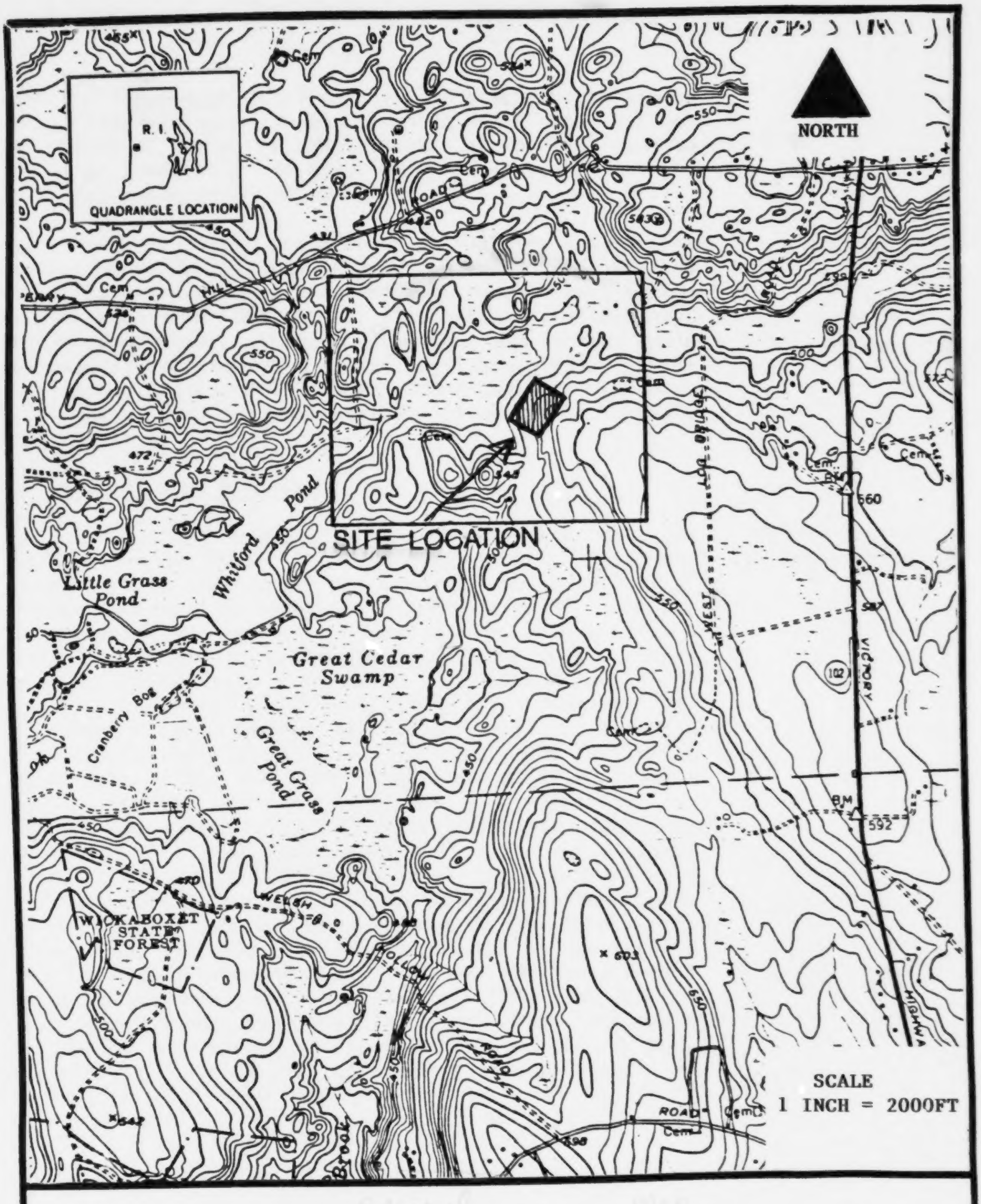
300.68(e)(2)(i)
(B) amount and
form of substances
present

300.68 (e)(2)(ii)
extent of migration

Background

The site owner, Warren V. Picillo, was involved in illegal dumping between 1975 and 1978 on an area in the rear of his property surrounded by woods and wetlands. The problem was first discovered September 30, 1977 after a fire and sodium aluminum hydride explosion occurred on-site. Rhode Island Department of Environmental Management (RIDEM) officials were notified and subsequently initiated a site investigation. They in-

300.63 (a)(4)
discovery



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Scale: 1"=2000'

Figure 1. Regional Site Location Map of Picillo Farm Site, Coventry, Rhode Island

Regional Map
Figure 1. Site Location, Picillo Farm Site, Coventry, Rhode Island

Source: Ecology & Environment 1981

spected the area on October 13, 1977 and found hazardous waste leachate seeping into a swamp 1,200 feet (357 m) northwest of the site. This unnamed swamp discharges to Whitford Pond, which at one time was a source of irrigation for a commercial cranberry bog.

300.63 (a)(2) government investigation

Sampling by the state found groundwater and surface waters contaminated with chlorinated and non-chlorinated volatile organic chemicals, and soil in the area contaminated with phthalate esters. Specifically, chloroform, trichloroethylene, toluene, benzene, and other toxic compounds were present in significant quantities. Later monitoring indicated that air quality had degraded near the swamp due to the release of volatile organic compounds.

Synopsis of Site Response

300.68(b) state remedial action

The initial response at the Picillo site was taken by the Picillo family in March 1978. Their action was pursuant to a court order and involved the removal of 27 drums that mostly contained ferric chloride, and the installation of several borings and monitoring wells. The first State-led action taken to correct the situation at Picillo was the removal of 14 drums of sodium aluminum hydride in July 1979. The material was disposed of at a secure landfill. Next, following a meeting between the State and U.S. EPA Region I personnel, EPA's Oil and Hazardous Material Spills Branch (OHMSB) section performed a preliminary investigation while a field investigation was undertaken by the State's contractor. After the site was declared eligible for Federal financial assistance, EPA's Solid and Hazardous Waste Research Division performed a more detailed study of the area. Based on the findings of this study, the State hired a contractor to excavate on the first four trenches. The State-led emergency action began on the northeast trench in June 1980 with the EPA assisting on-site by conducting air and surface water monitoring and by providing technical assistance when requested. During the northeast trench operation, excavation activities were halted on two occasions. First, on June 24, due to the unexpected large number of drums in trench, EPA's help was solicited for emergency containment. Second, on August 4, excavation ceased as a result of a town meeting during which a local group expressed concern over the amount of material being

300.65(a) immediate removal

stored above ground on-site. The community's concern prompted the State to being preparing for disposal activities before completing excavation. A total of 2,254 drums were removed by August 20, 1980 with a PCB-contaminated pile of soil left on-site. Waste disposal began on September 14, 1980, after testing the drum contents and bulk liquids. By October 10, 10-ton (9.1-metric ton) truck loads of crushed drums had been transported to a disposal site in New York and 157 barrels of acids, caustics, organic solvents and waste oil were sent to an approved waste management site in Massachusetts. At this time, 5 barrels were temporarily retained for evidence and 13 were kept for further sampling. On December 16, 1980, EPA's Enforcement Division had a local company remove 4,000 gallons (15,142 l) of contaminated PCB materials for off-site disposal.

300.65(b)(6)
moving hazarddous substances
off-site

Focus was then directed towards the northwest trench. A two-phased, joint EPA-State effort began in Janury 1981, after EPA formally initiated emergency response action at the site. According to the original plans, EPA's contractor was to prepare the site, excavate the drums, and store them temporarily on-site. EPA would provide security, utilites and fencing, and perform air and surface water monitoring. RIDEM's responsibilities included analysis of drum contents, drum disposal, groundwater and well water monitoring, and investigative activities. The state maintained control over all enforcement actions throughout the cleanup response at Picillo.

300.65(b)(3)
security

300.65(b)(5)
sampling

In March 1981, when the preparation of the site was 98 percent complete, it was announced that EPA's funds had been frozen. As a result, the responsibilities of EPA and RIDEM shifted and RIDEM became the lead agency. Between April 13 and June 12, 1981, RIDEM's contractor removed 4,350 drums from the northwest trench while EPA maintained security and utilities at the site.

Meanwhile, the Picillos filed a brief in conjunction with their appeal of the 1980 cleanup charges. Also, the Superior Court was in the process of assessing liability against the generators and the haulers of the waste.

300.68(c)
judicial
process

On July 22, 1981 EPA, RIDEM, and their contractor met in Providence, Rhode Island to discuss the disposal of the liquids stored on-site, a safety plan, and waste analytical data the State would supply. The safety plan was approved and the State received notice to proceed with liquid disposal operations at the end of July. During the next month, EPA removed almost 50,000 gallons

(189, 270 l) of flammable and corrosive liquids off-site to EPA approved disposal facilities, while 3,000 drums remained on-site. The disposal facilities that were used included SCA-Recycling Industries in Braintree, Massachusetts, Environmental Waste Recovery, Inc., in Coal City, Illinois and Waterbury, Connecticut and Connecticut Treatment Corporation in Bristol Connecticut. On September 1, 1983, 55 drums containing PCB material and 31 drums containing flammable solvents were removed for disposal off-site. Approximately 2,600 barrels of solid waste remained to be disposed of after testing.

300.71
worker health
and safety

Also in September, amid the ongoing emergency removal actions, EPA's Emergency Response Division in Washington, D.C. authorized the Region I office to obtain a hazardous substance release contract to dispose of the remaining drums with Superfund dollars. EPA began monitoring the preparations for disposal operations, which consisted of opening lab packs, separating the contents into "knowns" and "unknowns", and disposing of the unidentified material by detonation. (Sixty-three drums of waste acid and 14 drums of flammable trench leachate were removed for disposal).

300.61(c)
CERCLA financed
response

In October, sampling and analysis identified the contents of the remaining drums as: solids, sludges, residues from liquids, and filter papers. These substances, along with the previously identified materials, were eventually sent to disposal facilities in New York and Ohio.

300.65(b)(1)
evidentiary
sampling

300.67(c)(3)
hazardous substances in drums

Authorization to enter into a Cooperative Agreement for remedial work at the Picillo site was given on November 9, 1981, and on February 5, 1982, $4,938,590 was awarded to RIDEM. The money was to be used for excavation of the remaining two trenches, disposal of all of the barrels, treatment of contaminated soils, and a remedial investigation/feasibility study (RI/FS) to evaluate site conditions and to determine whether future action was necessary. At this time, all actions were still being implemented under the emergency response.

In March 1982, with approval of a waiver of the ceiling on emergency Federal funds, EPA began the disposal of the drums on-site. By April 1982, they had removed 1,467 drums, secured the site, and transferred the 1,172 drums remaining on-site to State authority, thereby ending the emergency response actions at Picillo.

300.65(c)
completion of
immediate
removal

As part of the remedial response initiated in April 1982, under the Cooperative Agreement, four contractors were hired. One contractor was asked to prepare a cost-effectiveness study for the planned remedial action; a second contractor was selected to remove the remaining drums from the site and excavate the west and the south trenches; the third contractor was hired to perform air monitoring; and the fourth was selected to conduct water quality monitoring and quality assurance work.

On May 31, 1982, excavation of the west and the south trenches was completed with 3,300 drums removed--much fewer than expected-- and three piles of soil left onsite, one contaminated with PCBs, the second with phenol, and the third with moderate concentrations of volatile organic compounds. Drum disposal began in June and was completed July 10, 1980.

300.70(c) off-site transport

Between August and September 1982, 1,700 cubic yards (1,299 m^3) of phenol-contaminated soil underwent landfarming treatment.

300.70(b)(2)(ii) (A) biological methods

In February 1983, RIDEM requested that a consulting firm prepare a site closure remedial investigation/ feasibility study, including a final risk assessment, and an evaluation of groundwater contamination, including an assessment of the need or the feasibility to treat it. The report, submitted in August 1983, did not meet EPA criteria, and consequently, no site closure or groundwater treatment plans were developed. In February 1984, after the site was reclassified as an EPA enforcement-lead site, EPA's technical enforcement support contractor was asked to undertake a second feasibility study. This report, due in November 1984, may call for further remedial action at Picillo.

SITE DESCRIPTION

The Picillo Farm site is located approximately at 41° 40.4' north latitude and 70° 42.5' west longitude, one mile southwest of the intersection of Route 102 and Perry Hill Road (Figure 2). Situated in a predominantly rural farm area, the 7.5-acre (3-ha) disposal site is located in the corner of what was once a 55-acre (22-ha) former pig farm. The site occupies cleared ground and is surrounded by woods and wetlands. Along Route 102, within a 1-mile (1.6-km) radius, there are approximately 50 homes, representing 176 residents.

Surface Characteristics

The topography in the site area consists of sloping terrain. The site itself is located at an elevation of 550 feet (168 m) above mean sea level (MSL) along the northwest flank of a northwest-southeast aligned hill (Figure 1). The hill slopes downward to the north, northwest, west, and southwest of the disposal site, while to the southeast, land elevation increases. The northward slope is toward a low-lying meadow that is bordered farther north by a swampy area and a bedrock highland. The northwestward and westward slopes are toward an unnamed that drains into Whitford Pond approximately 1,000 feet (305 m) farther to the west. The southwestward slope is toward Great Cedar Swamp, which drains into Great Grass Pond.

The surface water drainage system in the site area is part of the Quinebaug River Basin (Ecology and Environment, Inc. 1981). The basin is bounded on the east by a drainage divide running through the Picillo property (Figure 3). Surface water east of this divide is part of the South Branch of the Patuxent River Basin and flows east towards Quidnick Reservoir. Water west of the divide flows southwest. There are two separate distinct drainage patterns that carry surface water away from the site area: (1) a perennial unnamed tributary that originates at a spring about 400 feet (122 m) east of the Capwell Cemetery and flows northeast to the Quidnick Reservoir; and (2) surface water drains to the unnamed swamp located to the west-northwest and then into Whitford Pond. The water from Whitford Pond flows through cranberry bogs and into Roaring Brook, which eventually converged with the Moosup River.

Soils at the Picillo site are members of the order known as Spodosols. These soils are characterized as having an accumulation of amorphous materials consisting of organic matter plus compounds of aluminum and usually iron. They are formed in acidic conditions from mainly course-textured materials in humid and mostly cool or temperate climates. Spodosols are generally known as acid, ashy, gray sands over dark, sandy loams. Within the Spodosol order, the soils at Picillo are classified as being members of the Haplorthod and Fragiorthod subgroups. These soils are moderately sloping and form in both loamy and sandy sediments. They are more or less freely drained and have or have had a forest vegetation that consists either of hardwood trees or conifers.

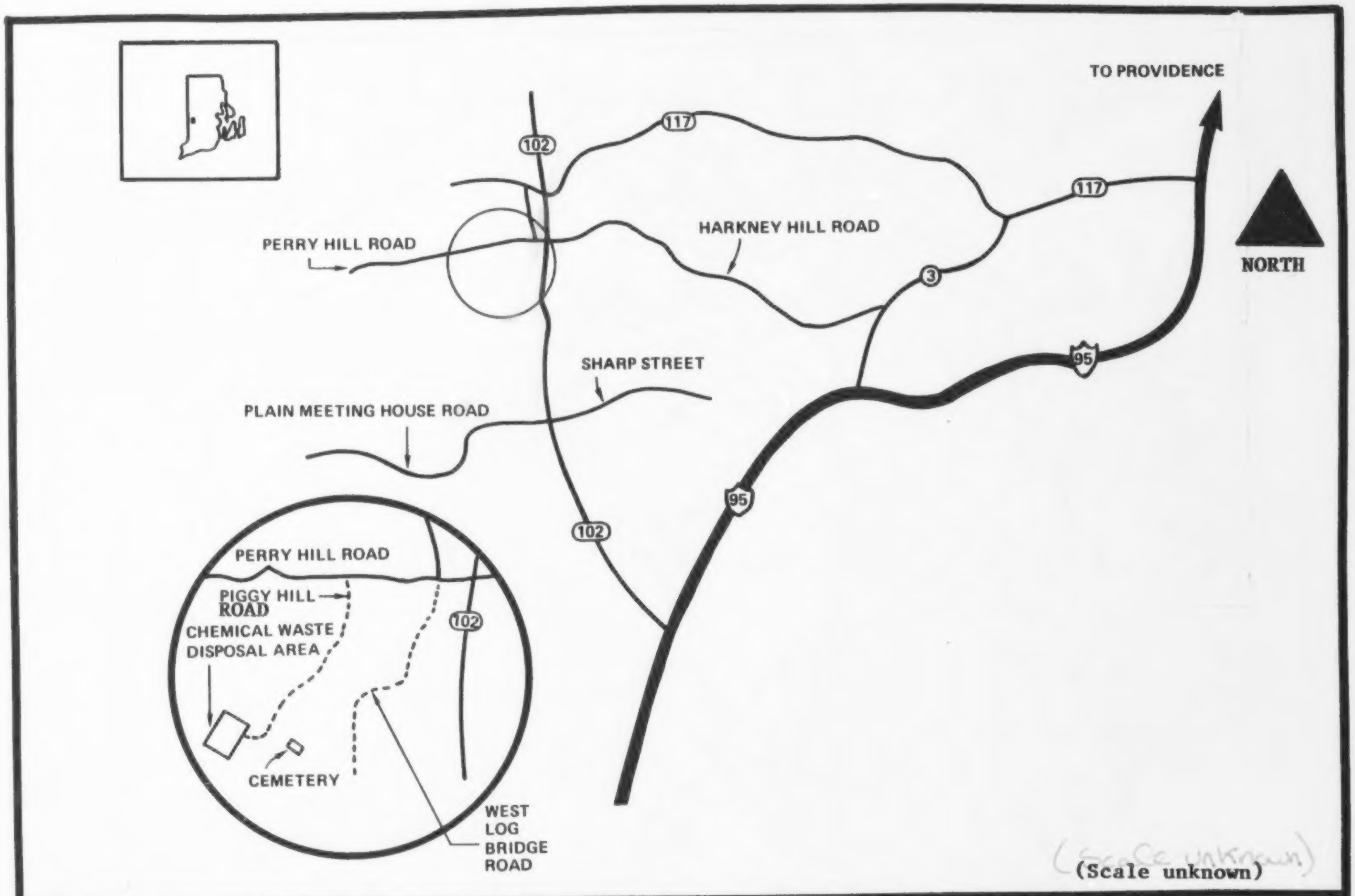

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Figure 2. Site Location Map, Picillo Farm Site, Coventry, RI

Figure 2. Site Location Map, Picillo Farm Site, Coventry, Rhode Island

Source: Mitre 1980

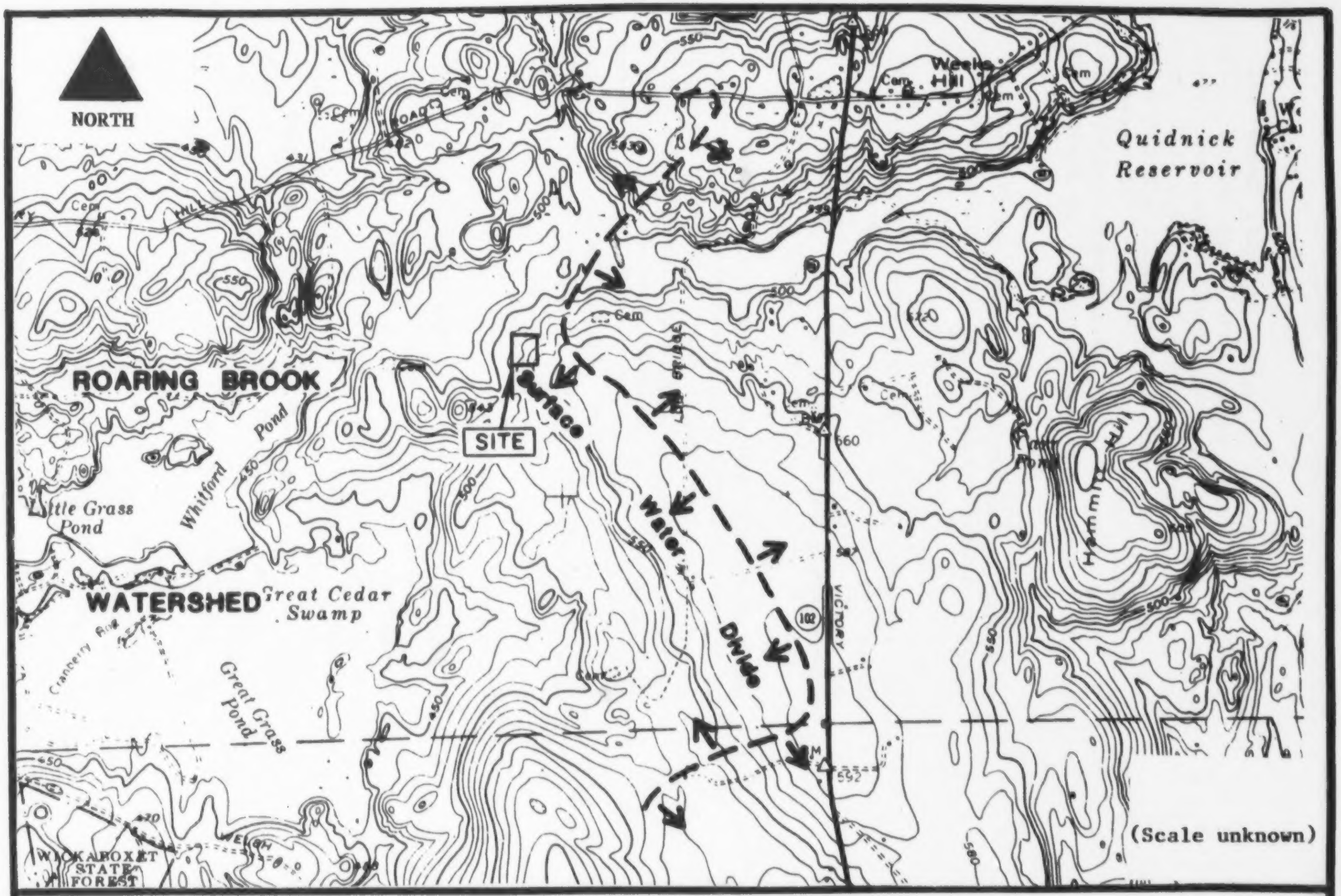

Figure 3. Regional Map Showing Surface Water Divide Through Picillo Site

Source: Tighe & Bond 1983

The local climate is classified as humid continental. During the winter months of December through February, the normal daily average temperature ranges between 30°F and 35°F. Normal average daily temperatures during the spring season (March, April, and May) are between 35° and 50°F. The summer months bring average daily temperatures between 70°F and 75°F. Autumn average daily temperatures range between 50°F and 65°F.

300.68(e)(2)(i)
(E) climate

The prevailing annual wind direction is northeasterly, with an annual mean speed ranging between 9 and 12 miles per hour (14.5-19.3 Km/hr).

Normal total precipitation during January and February is 2 to 4 inches (5-10 cm). During the months of March and April, the amount of rain that falls in the site area doubles, with a normal total precipitation ranging from 4 to 8 inches (10-20 cm).

During the 6-month span from May through October, precipitation values decrease, with normal monthly total precipitation between 2 and 4 inches (5-10 cm). During the month of November, rainfall increases to a normal monthly total of 4-8 inches (10-20 cm), decreasing again in December with a total of 2-4 inches (5-10 cm). The normal annual precipitation in the site area is 45 inches (114 cm). Mean annual total snowfall is 36 inches (91 cm).

Hydrogeology

The hydrogeologic system in the vicinity of the Picillo Farm site consists of unconsolidated glacial deposits, predominantly poorly sorted till, and moderately well-sorted, stratified drift of varying thicknesses. The glacially-deposited materials overlie metamorphic bedrock that is fractured at its surface and at its depth. The bedrock surface is generally reflected by the land surface topography (Figure 4). Groundwater generally flows from southeast to northwest through the study area and then discharges to the unnamed swamp.

300.68(e)(2)(i)
(D)
hydrogeological
factors

Previous hydrogeologic investigation reports (Mitre 1980a); Ecology and Environment, Inc. 1981) reveal that basal till covers most of the bedrock surface in the

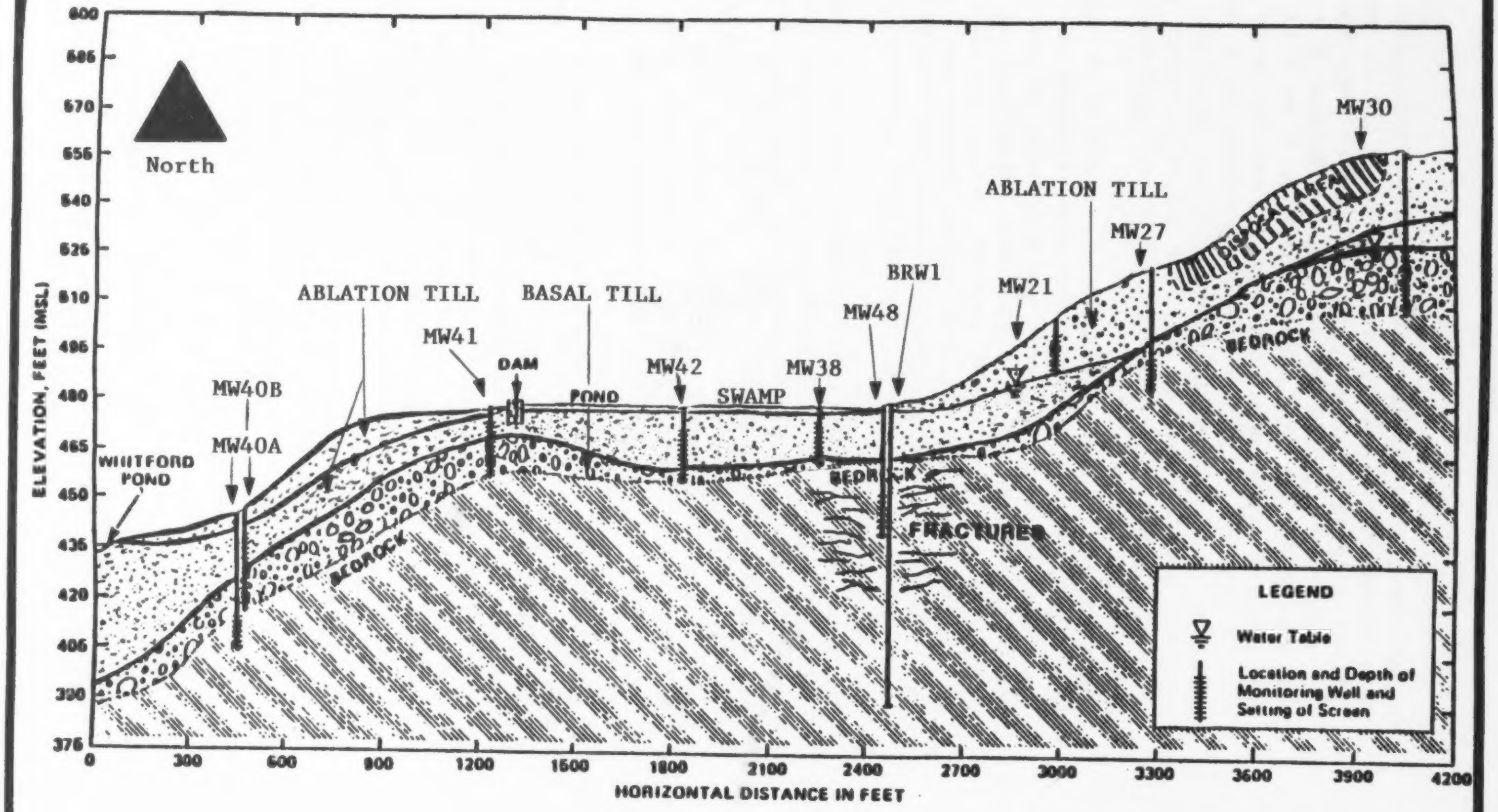

Figure 4. Geologic Cross-Section Between Picillo Farm Disposal Site and Whitford Pond

Source: Tighe& Bond 1983

study area. The basal till consists of a gray, dense mixture of silt and fine sand, with minor amounts of clay and cobbles of the local bedrock, granite gneiss, which was eroded by glacial activity. Overlying the basal till is a stonier, denser ablation till composed of a brown to tan mixture of course sand, gravel, and cobbles with minor amounts of silt. Generally, the tills increase in density with depth, from a loose stoney material on or near the surface to more cohesive strata resting directly on the bedrock surface below.

The thicknesses of both tills vary across the study area. In general, the thickest till deposits occur in the highland areas, while the thinnest deposits are found in the swampy lowlands. During the installation of monitoring wells in the study area, till thicknesses encountered ranged from 10 to 20 feet (6-3 m) in the highland and swampy lowlands, respectively (Ecology and Environment, Inc. 1981).

The surficial deposits that overlie the ablation till are described as stratified drift. This material was originally till and later reworked by glacial meltwater. Collectively, these deposits are termed as glaciofluvial due to their deposition by running water. They consist of tan to brown, coarse to fine, clean sand with traces of silt, gravel, and cobbles (Ecology and Environment, Inc. 1981).

Overlying the glaciofluvial deposits in the swampy lowlands are dense, stratified deposits that consist of gray silt and clay. These are lake deposits that were initially suspended in ponded areas of the swamp and then settled out in layers onto the lake bottom. Ponding of the swamp was caused by the construction of a fieldstone dam at the western-most end of the unnamed swamp (Ecology and Environment, Inc. 1981).

The remaining surficial materials that occur in the study area are swamp deposits consisting primarily of peat. These deposits are located north and northwest of the disposal site in the unnamed swamp. They are also present south of the site in Great Cedar Swamp. The swamp deposits in the unnamed swamp consist of about 7 feet (2 m) of peat overlying lake bottom deposits and either glaciofluvial deposits or till that have accumulated in poorly drained areas. The deposits in Great Cedar Swamp are presumed to exhibit similar stratigraphy (Ecology and Environment, Inc. 1981).

The bedrock that underlies the previously described deposits is granite gneiss, a metamorphic rock belonging to the Ten Rod granite gneiss formation. It is highly weathered and is fractured to a depth of at least 15 feet (4.5 m). It consists of fine-grained, gray and white gneiss in the lowland areas, and a somewhat more resistant, but still weathered and fractured, course-grained gneissic granite in the highlands.

The bedrock surface beneath the disposal site slopes northeast to south in a fan-shaped configuration toward the meadow on the northeast and north, toward the unnamed swamp from northwest to west, and toward Great Cedar Swamp to the south. A bedrock trough, bounded on the north and the south by bedrock highlands, slopes gently east to west through the meadow and into the unnamed swamp. The trough continues westward where it dips steeply toward Whitford Pond. The slope of the bedrock surface varies across the site area from 0.3-8.0 percent.

Groundwater in the study area occurs within two hydraulic interconnected unconfined aquifers: (1) an unconsolidated aquifer consisting of basal and ablation till, glaciofluvial deposits, and swamp deposits; and (2) a fractured bedrock aquifer. As previously described, the Picillo site is located within the Quinebaug River Basin, in which regional surface water and groundwater flow is toward the southwest, eventually passing into Connecticut (Ecology and Environment, Inc. 1981). However, the groundwater flow in the immediate study area deviates from the southwesterly regional trend. Hydrogeological studies conducted by various consultants (Ecology and Environment, Inc. 1981; Mitre 1980a; and Tighe & Bond 1983) indicate groundwater flows radially from the east across the site to the northwest, west, and southwest (Figure 5). Due to the unconfined nature of both aquifers (i.e., the water table surface is at atmospheric pressure), flow is primarily lateral and strongly controlled by differences in the hydraulic gradient (slope of the water table) and, in the case of the bedrock, the strike and the dip of the fracture pattern.

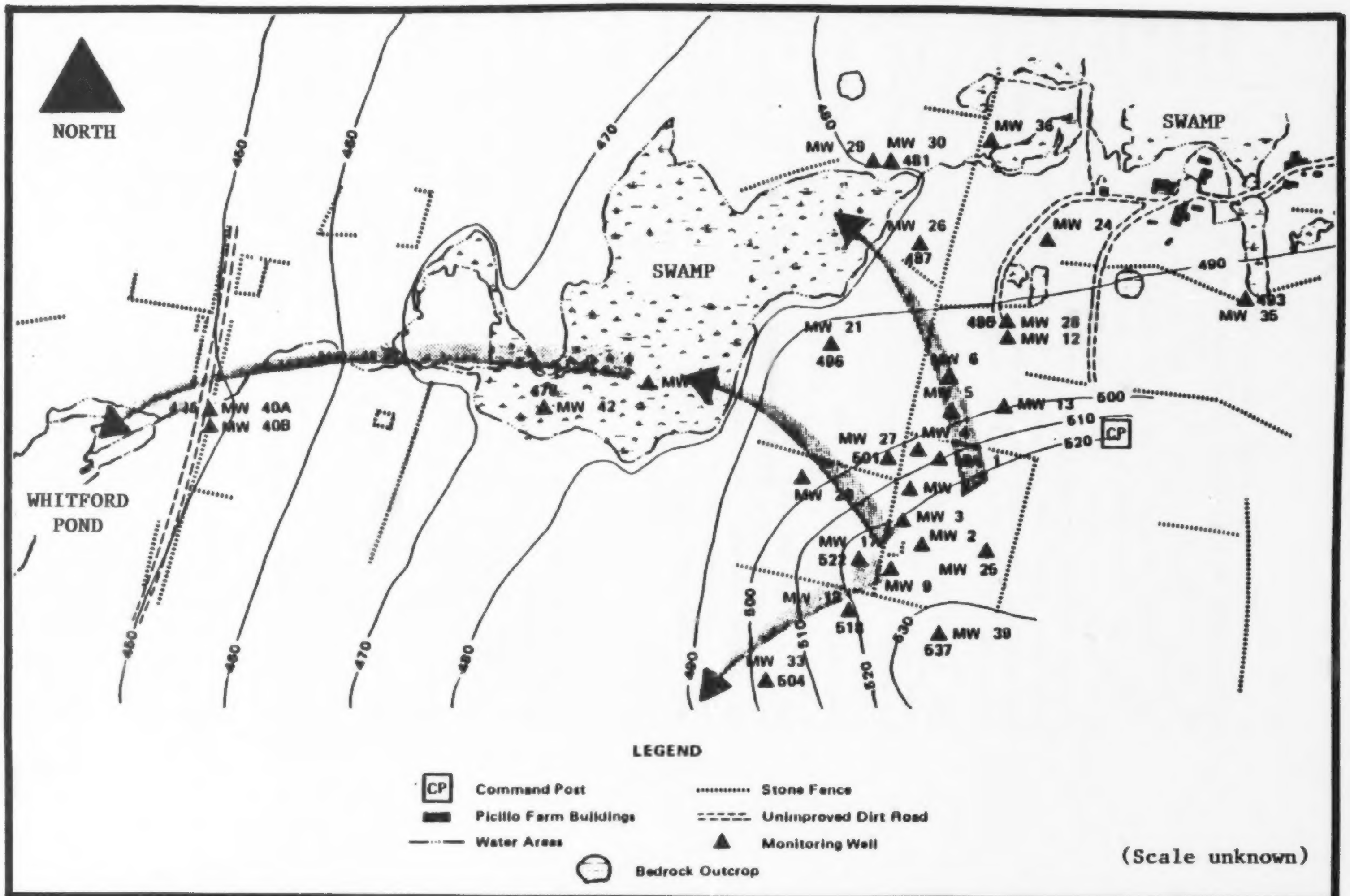

Figure 5. Ground Water Flow Directions in the Vicinity of the Picillo Farm Site, Coventry, Rhode Island

Source: Ecology & Environment 1983

Groundwater in the study area also flows in a vertical direction from areas of high to low hydrostatic pressure. The vertical movement is governed by hydraulic conductivities of the unconsolidated deposits in contact with the bedrock surface, the hydraulic conductivity of the bedrock, and by differences in hydrostatic pressure between the two units. Since the unconsolidated deposits have a slightly higher hydrostatic pressure than the bedrock, it has been concluded that there is a slight downward component of groundwater flow from the unconsolidated to the bedrock aquifer.

Groundwater velocities for various areas in the study area were estimated using general hydraulic conductivity and porosity values for the different types of deposits present in the vicinity of the site. Table 1 indicates that groundwater velocities are greatest through glaciofluvial deposits. This material has a slow silt and clay content, thus it permits easy flow of groundwater. In comparison, the till and swamp deposits have high silt and clay contents, which tends to decrease the groundwater flow rate through them. Groundwater velocities through the bedrock vary depending on the frequency of fracturing.

WASTE DISPOSAL HISTORY

The Picillo Farm site was used as a hazardous waste disposal site between 1975 and 1977 by unidentified generators and haulers. No records of origin, type, or quantity of materials disposed at the Picillo property were ever discovered. However, following the three phases of excavation, specific substances were identified. Sample analysis indicated that a variety of organic and inorganic chemicals may have been deposited at Picillo, including industrial solvents, PCBs, pesticides, paint sludges, plasticizers, resins, explosives, and chlorinated compounds. The substances identified during removal and disposal operations at Picillo are noted in Table 2.

TABLE 1. ESTIMATED GROUNDWATER FLOW RATES, PICILLO FARM, COVENTRY, RHODE ISLAND

	Till (K=10 to 10^{-3} ft/day) (3 to 3 x 10^{-3} m/day) (P=.45)	Glaciofluvial Deposits (K=10 to 10^{2} ft/day) (3 to 30 m/day) (P=.35)	Swamp Deposits (K=10 to 10^{-2} ft/day) (3 to 3 x 10^{-2} m/day) (p=.60)	Bedrock (K=1 to 10^{-5} ft/day) (.3 to 3 x 10^{-5} m/day) (p=.01)
Disposal Site to Unnamed Swamp (i = .03 ft/ft)	.66 to 6.6 x 10^{-5} ft/day	.85 to 8.5 ft/day	N/A	3 to 3.0 x 10^{-5} ft/day
Disposal Site to Great Cedar Swamp (i = .04 ft/ft)	.88 to 8.8 x 10^{-5} ft/day	1.1 to 11.4 ft/day	N/A	4 to 4.0 x 10^{-5} ft/day
Unnamed Swamp to 10^{-6} ft/day Dam (i = .003 ft/ft)	.06 to 6.6 x 1^{-6} ft/day	.08 to .85 ft/day	.05 to 5.0 x 10^{-5} ft/day	.3 to 3.0 x 10^{-6} ft/day
Dam to Whitford pond (i = .07 ft/ft)	.5 to 1.5 x 10^{-4} ft/day	2 to 20 ft/day	N/A	7 to 7.0 x 10^{-5} ft/day

Source: Ecology and Environment, Inc. 1981

The area used for dumping consisted of 7.5 acres (3 ha) and housed six trenches. The first two trenches, together known as the northeast trench, were each 50 feet (15.24 m) wide, 100 feet (30.48 m), 70 feet (21.34 m) long, and up to 35 feet (10.67 m) and 25 feet (7.62 m) deep, respectively. A total of 2,300 55-gallon (250-l) drums of which 1,800 contained liquids and solids were removed from this trench. The upper layer of barrels was crushed. Approximately 70 percent of the chemical-containing drums were leaking or corroded and many burst open. As a result, 10,000 cubic yards (7,645m^3) of earth were contaminated. According to a site representative, the deteriorated condition of the drums was due to bulk discharge of acid into the trenches, thereby corroding the buried drums and causing the release of additional acid from some of those drums.

300.68(e)(1)(v)
highly contaminated
surface soils

The northwest trench also consisted of two parallel trenches, each measuring approximately 250 feet (76.2 m) long, 25 feet (7.62 m) wide, and 25-35 feet (7.62-10.67 m) deep. From this trench, 4,400 drums were removed, of which 2,000 contained solids and 1,900 contained liquids. Similar to the barrels found in the northeast trench, their condition was fragile and deteriorating.

The last two trenches, excavated as one project, contained 3,300 drums in total, the majority being removed from the west trench. The west trench was the larger of the two, measuring 360 feet long (109.7 m) by 30 feet wide (9.14 m) by 25 feet deep (7.62 m). Approximately 640 barrels labeled "highly toxic" were dumped into the center of the west trench after the 1977 fire. However, according to RIDEM accounts, the drums removed were in better condition than those disposed of in the previous two trenches. The area referred to as the south trench measured 50 feet long (15.2 m) by 25 feet wide (7.62 m) by 25 feet deep (7.62 m), and contained only a small number of barrels.

For the most part, drums were randomly stacked and appeared to be present in clusters rather than being uniformly dense throughout a trench. Thus, the drums appeared to have been pushed into the trenches and covered periodically with earth, thereby producing the clusters. Certain sections had been run over by bulldozers to compact and crush the drums and many drums

TABLE 2. WASTE TYPES FOUND AT PICILLO FARM, CONVENTRY, RHODE ISLAND

LIQUIDS	SOLIDS	LAB PACKS
organics solvents (flammable, non-flammable, halogenated, non-halogenated) acids caustics, cyanides, PCBs (sludges and liquids)	paints resins PCB filters spent charcoal	laboratory samples spent reagents flammable solids explosives

Source: EPA 1984 a

were without bungs so that the contents drained out during or after burial. However, there were, some instances where several drums seemed to be stacked neatly. Subsurface pockets of nested liquids, identified as "plumes" by ground-penetrating radar surveys, were a result of sludge and semi-solid materials isolating and blocking empty spaces.

DESCRIPTION OF CONTAMINATION

Field Investigation

Studies to define the extent of contamination at the Picillo Farm site were first initiated during the fall of 1977 when the State of Rhode Island closed the dumping operations at the site and began their investigation. The first groundwater samples were collected and analyzed in the spring of 1978 following installation of the initial group of monitoring wells under the direction of RIDEM. Sampling and analysis of these wells continued until the fall of 1979, when a consulting firm was contracted by the State to begin a more detailed investigation.

300.65(b)(5)
sampling

This field investigation consisted of two phases. The first phase included an electrical resistivity and metal detection survey, monitoring well installation, and the collection and analysis of soil, surface water, and groundwater samples. The Phase I report was completed in April 1980. Phase II of the investigation included ground-penetrating radar and a seismic refraction survey, bedrock sampling, and generated additional sample analysis results. Phase II concluded with a report in February 1981.

In the spring of 1980, the Oil and Hazardous Materials (OHM) Section of EPA Region I became involved with the Picillo site. As part of its effort, OHM initiated a comprehensive surface water sampling program in May 1980. The surface water drainage area covered by this sampling program extended as far east as the Quidnick Reservoir and as far west of the site as Roaring Brook (see Figure 3), which drains the cranberry bogs. Samples were collected at regular intervals through August 1981.

In February 1981, EPA's Field Investigation Team obtained samples from groundwater monitoring wells, surface water points, and a soil pile that had been generated during initial trench excavation activities in August 1980.

Field Investigation Findings

The data generated by RIDEM and the Phase I studies provided an initial representation of the types of contaminants present and the extent of contamination immediately adjacent to the disposal site. Resistivity measurements from these initial studies identified the boundaries of two leachate plumes that corresponded to the major groundwater flow directions to the northwest and southwest that had been identified earlier. Both plumes were identified as covering large areas downgradient from the disposal trenches and appeared to be discharging toward the unnamed swamp and the stream to the west and north, respectively.

300.68(e)(3)(1)
water pollution

Total volatile organic (TVO) concentrations in groundwater samples generally corresponded to the leachate plume boundaries as identified by the resistivity survey. Figure 6 shows the location of monitoring wells and surface water sampling stations in the study area. Initial sampling analyses results are given in Tables 3 and 4.

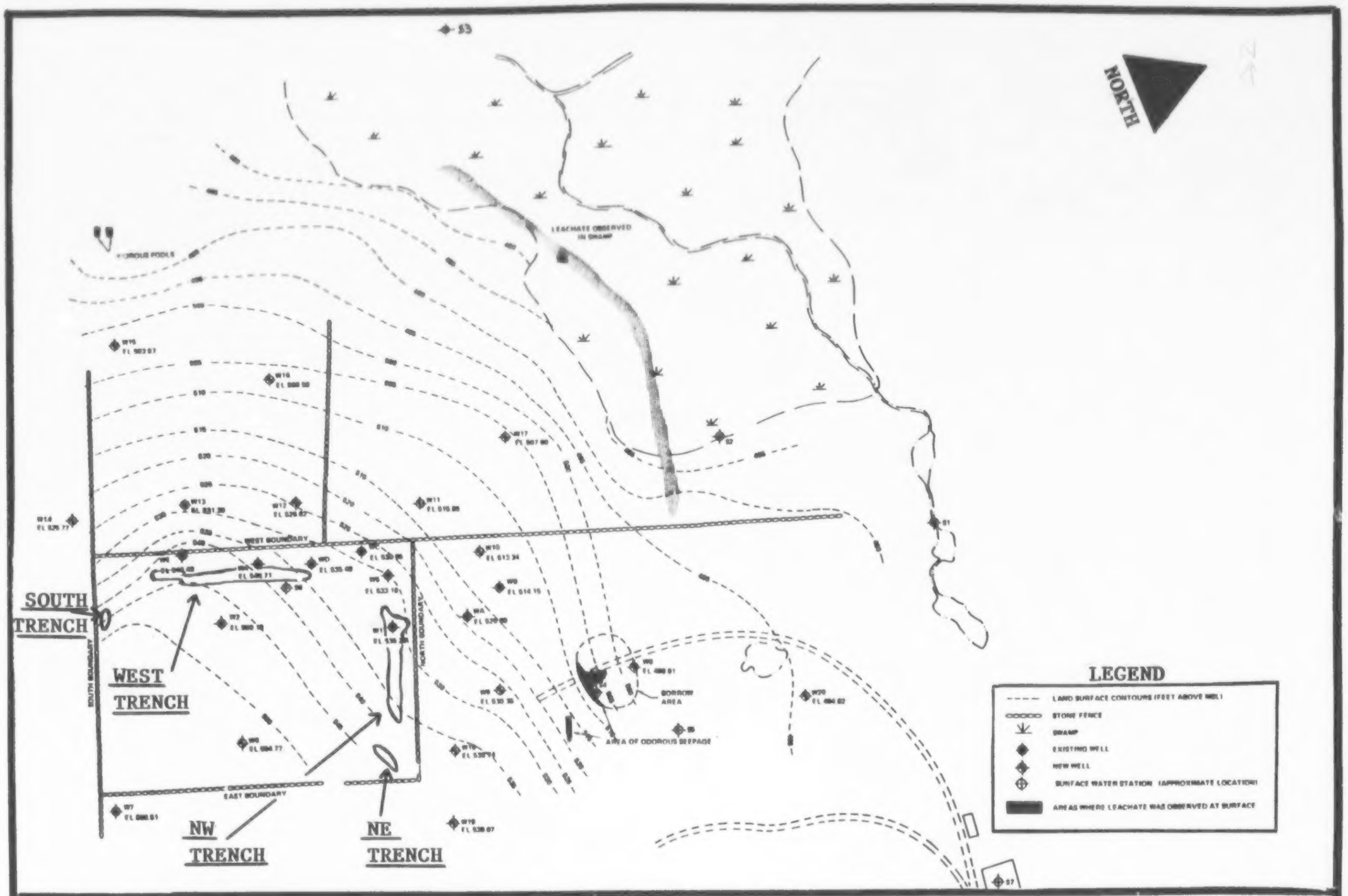

Figure 6. Ground Water and Surface Water Sampling Locations at the Picillo Farm Site, Coventry, Rhode Island

Source: Mitre 1980

TABLE 3. TOTAL VOLATILE ORGANIC CONCENTRATIONS IN WATER AND SOILS

Sampling Station	TVO Concentration (parts per billion)						
	Water	Soil (approx. depth below surface in feet)					
		0-1 ½	2-3 ½	5-6 ½	10-11½	15-16 ½	20
Monitoring Wells							
2	400						
4	1,000						
5	16,000						
6	300						
7				500			
8	46,000	1,400	100	100	400	200	100
9				1,500	300		100
10				300			
11			100	100	100		
12							
13			1,000		400	100	1,000
14				100	100		
15	1,300	300		200	1,100	400	
16	4,900		100	100			
17	3,900	5,100		400	900	4,000	
18		100		400	200	900	100
19	300			200	2,700	1,200	500
20	1,000				100	200	700
B	45,000						
D	5,000						
E	19,000						
Surface Water							
1	200						
2	33,000						
3	500						
4	100						
5	100						
6	100						
7	100						

Note: See Figure 6 for sampling station locations.

Source: Mite 1980a

TABLE 4. SUMMARY OF CONSTITUENTS IDENTIFIED BY THE PRIORITY POLLUTANT ANALYSIS

	Concentration (ppb)					
	Water			Sediment		
	5 & D	A & 18	13 & 14	17 & 10	9 & 18	13 & 14
Acid Compounds						
2-nitrophenol	24	68	660			
phenol	1,300	87	820		420	120
Total Acid Compounds	1,324	155	1,480	0	420	120
Base/Neutral Compounds						
bis(2-choroethyl)ether		50				
1,2-dichlorobenzene	11					
"isophrone derivative"*	59	650	7,600			
hexachlorobutadiene			15			
bis(2-ethylhexyl)phthalate				500	230	160
butyl benzyl phthalate				55		
di-n-butyl phthalate				57	24	12
diethyl phthalate		48		14	61	
benzo(a)anthracene/chrysene				13		
phenanthrene				30		
naphthalene			10			
nitrobenzene			110			
Total Base/Neutral Compounds	70	748	7,735	669	315	172
Volatiles						
benzene	240	300	56			
chlorobenzene		200				
1,2-dichloroethane		160	21			
1,1,1-trichloroethane	1,100	1,000	590			
1,1-dichloroethane		17	34			
chloroform	1,000	1,500	310			
1,1-dichloroethylene		430	100			
ethylbenzene		290	180			
methylene chloride	8,100	1,700	500	15	330	32
methyl chloride				95		17
trichlorofluoromethane		470				
tetrachloroethylene		180	75			
toluene	2,900	1,000	180			
trichloroethylene	200	590	86			
xylenes		120	69			
Total Volatiles	13,540	7,957	2,201	101	330	49
Metals						
cadmium	8	0.6	0.8			
copper	25			6		
nickel	90	7				
lead		9				
zinc	220	55	50		20	13
silver	0.5					
Total Metals	344	72	51	6	20	13
Pesticides						
PCB-1248				110		

* This particular derivative is not a priority pollutant. It could not be specifically identified by ERCO.

Source: Mitre 4/80

Note: See Figure 6 for sampling station locations.

Water from upgradient wells (W2, W6, and W19) averaged 3.4 ppm (mg/l) TVO, while samples from wells directly downgradient from the trenches (W4, W5, WB, WD and WE) had an average TVO concentration of 17.2 ppm (mg/l). Samples obtained from locations further downgradient (W8, W15, W16, W17, and W20) averaged 11.4 ppm (mg/l) TVO. This reduction in contaminant levels indicates that there is a dilution mechanism in the groundwater flow system influencing contaminant levels (Table 3).

Three composite groundwater samples were also analyzed for the entire list of priority pollutants. Table 4 summarizes the results of the concentration of priority pollutants above detectable limits. In comparing TVO and priority pollutant analysis results from groundwater samples, it was found that total volatiles were present in higher concentrations than any other type of compound. Total concentrations of acid compounds and the concentrations of any one metal were not found to be significant. The presence of several toxic compounds were identified; however, none were present in significant concentrations.

Surface water sample analyses results corresponded to the general water quality trend suggested by the groundwater samples (Tables 3 and 4). The upgradient sample (S1) had a TVO level of 0.2 ppm (mg/l), while the sample collected from the swamp (S2) had a concentration of 33 ppm (mg/l). The TVO concentration at S3, approximately 1,000 feet (30.5 m) downgradient from S2, was 0.5 ppm (mg/l). This reduction in TVO concentration between S2 and S3 may have been indicative of either mixing and dilution within the swamp, discharge of groundwater with low TVO levels, or removal of contaminants by volatilization.

Contaminant levels in soil samples were generally much less than those in surface and groundwater samples. The average TVO concentration found in soils in the study area was 2.1 ppm (mg/l), as compared to 17.2 ppm (mg/l) from monitoring well samples. However, low TVO levels in soil did not always correspond to low TVO levels in groundwater, as indicated by the relatively high TVO concentration, 2.7 ppm (mg/l), in soil from W19, which is upgradient.

The total concentration of base/neutral (B/N) compounds was less in soil samples than in water samples. As with water samples analysis results, concentrations of acid compounds and metals in soils were not found to be significant. One composite soil sample showed a concentration of 110 ppb (mg/l) PCB-1248. No pesticides were detected in the soil samples collected at this time. The presence of several other toxic compounds were identified, but not in significant concentrations (see Table 4).

In conclusion, the results from the early investigative studies conducted at the Picillo site indicated the existence of a number of priority pollutants. The following five were of the most concern despite their low (1 ppm; mg/l) concentrations because they are considered to be either carcinogenic (cancer-causing), mutagenic (chromosome-altering), or teratogenic (fetal-deforming) (Mitre 1980a):

- Benzene
- Nitrobenzene
- 1,2-dichloroethane
- Trichloroethylene
- Chloroform.

Phase II of the investigation was conducted to obtain additional information necessary to define the public health risk presented by the site and to evaluate methods for abatement of the problem. Study parameters included:

300.68(f)
remedial
investigation

- Location, condition, and number of buried drums
- Depth, topography, and permeability of bedrock
- Effectiveness of the swamp as a treatment mechanism for volatile organic chemical contamination.

To generate this additional information, Phase II field activities involved the use of ground-penetrating radar, seismic refraction profiling, installation of additional monitoring wells, bedrock permeability testing, soil and water sampling and analysis, and limited excavation.

Results from the Phase II field tests gave approximate sizes and boundaries of the four disposal trenches and indicated that about 70 percent of the buried drums were leaking or corroded. The number of whole, uncrushed 55-gallon (208-l) drums buried at the site was estimated to be between 16,700 and 44,700.

300.68(e)(2)(i)
(B) amount and
form of substances present

A key purpose of the Phase II activities was to determine the depth, topography, and relative fracturing of the bedrock and the hydraulic conductivity of the unconsolidated deposits. It was found that bedrock generally occurs 10 to 30 feet (3-9 m) deeper than anticipated; the actual depth varies from less than 10 feet (3 m) near the unnamed swamp to 70 feet (21 m) at the disposal site. It was also found that the bedrock is highly fractured through the upper 10 to 15 feet (3-5 m) and is hydraulically connected to the overlying glacial deposits. Permeability testing within the fractured bedrock and the overlying deposits indicate, hydraulic conductivities of 10^{-6} cm/sec ($3x10^{-7}$ ft/sec) and 10^{-4} to 10^{-5} cm/sec ($3x10^{-5}$ to $3x10^{-6}$ ft/sec), respectively.

The question of whether the swamp is acting as an effective treatment mechanism for volatile organics was not answered during this investigation due to the low flow conditions that occurred during the July 1980 sampling period. However, both phases of RIDEM's sampling program suggest that the chemical contamination existing in the swamp areas is being eliminated by volatilization.

Phase II organic and inorganic analyses further substantiated the conclusion from previous studies that contamination of the groundwater is predominantly caused by the presence of volatile organic compounds.

Sampling and analysis results from the FIT's 1981 investigation confirmed the presence of concentrations of volatile contaminants in the groundwater flowing northwesterly and southwesterly from the disposal site. The FIT sampling and analysis effort also identified the major contaminants at the site. In addition to water sample analyses, FIT collected and analyzed samples from the contaminated soil pile generated by trench excavation activities and located at the southeast corner of the site. These soil samples exhibited PCBs, in addition to various priority pollutant organic compounds.

In the fall of 1983, following the completion of remedial actions and the preparation of the Remedial Investigation/Feasibility Study for the site, another investigation was initiated. EPA asked their Technical Enforcement Support (TES) contractor to conduct a comprehensive review of all existing data and information on the Picillo site. With this data, the TES performed an endangerment assessment to characterize the type and the extent of contaminants found both on and off the site, and assess their associated hazards.

The conclusions presented below regarding the extent of contamination at the Picillo site are based upon the TES' endangerment assessment (GCA 1984a), FIT investigation, as well as previous studies conducted at the site:

- The principal groundwater contaminants are volatile organic compounds. Those contaminants present in highest concentrations include acetone, 1,1,1, trichloroethane, toluene, chloroform, methylene, chloride, methyl ethyl ketone, tetrahydrofuran and trichloroethylene.

- Contaminant concentrations in groundwater have varied over time, due to a variety of factors affecting the release onto and movement through the groundwater.

- Groundwater is not used as a drinking water source, nor is it used for irrigation purposes.

- Hydrologic and analytical data confirm that contaminated groundwater is moving in two general directions: (1) toward the unnamed swamp northwest of the site, and (2) off the southwest corner of the site toward Great Cedar Swamp.

- The contaminant plumes emanating from the site are subject to dispersion, volatilization, adsorption, and degradation, which act to decrease downgradient contaminant concentrations.

- Hydrologic and analytical data indicate that surface water and groundwater do not flow from the site to the north-northwest, toward Quidnick Reservoir. Analytical results show no signs of contamination in the resevoir area; therefore, it has been concluded that contaminants are not moving toward this resource.

- There is neither hydrologic nor analytical data that suggest that there is a component of groundwater flow that moves off the site and under the swamp.

- The unnamed swamp represents a discharge zone in the site area. Groundwater from surrounding upland areas of recharge converges beneath the swamp, producing opposing flow components. This results in the development of a no-flow boundary beneath the discharge area, causing the northwest plume to flow upward into the peat deposits. These conditions are supported by consistently high levels of many volatile organic compounds found in surface water samples collected from the interior of the unnamed swamp.

- The swamp plays a major role in reducing the level of contaminants in the groundwater through volatilization of aromatic hydrocarbons and volatile chlorinated organics.

- Volatilization of contaminants from the surface water of the swamp has a minimal impact on air quality in the study area. At no time did organic vapor surveys indicate vapor concentrations above ambient background levels (3-4 ppm; mg/l).

- The contaminated pile of soil on the southern boundary of the disposal site may be serving as a localized source of low-level contamination of groundwater flowing south from the site.

- No contaminants related to the Picillo site have been detected in residential wells adjacent to the study area.

- The contaminated groundwater at the Picillo site has been found to pose no imminent threat to human health or to the environment.

PLANNING THE SITE RESPONSE

Initiation of Site Response

Shortly after the fire and explosion at the Picillo Farm site in September 1977 and until mid-1979, RIDEM conducted field studies to quantify the seriousness of the situation. Also during that time, the State attempted unsuccessfully to employ several legal measures to compel Picillo--who did not have a license to operate a solid waste management facility in Rhode Island--to clean up the site.

Soon after the fire and explosion, the State gained access to the site. An October, inspection by the State Fire Marshall led to an order that the site owners remove all combustible materials from the property. In regard to a suit filed by RIDEM and the Rhode Island Attorney General's Office, the Rhode Island Superior Court issued a Temporary Restraining Order on October 18, 1977 that required the Picillos to obtain prior authorization from the State Attorney General to dispose, bury, or remove any wastes previously dumped on the property. The next measure was a Preliminary Injunction, issued November 18, 1977, which enjoined Warren and Selina Picillo from hazardous waste storage, burial, or disposal on their property; requested them to remove and to dispose of all materials at a State-approved facility; ordered them to contract with qualified professionals to study the potential for groundwater contamination; and asked that a final report be delivered to the court by December 14, 1977. On

300.68(c)
administrative
process

March 13, 1978, pursuant to the court order, the Picillos removed 27 drums of various wastes, (mainly ferric chloride), from the site to an approved facility in Braintree, Massachusetts for proper disposal. In April, Picillo had borings and monitoring wells installed. No other terms of the injunction were complied with, and consequently, the Picillos were found to be in civil contempt.

By May 1979, it appeared that the defendants were either unwilling or unable to undertake the necessary remedial action, and the State Superior Court Judge directed the State to take control of the situation. RIDEM hired a consulting team with State funds to study options for removing the wastes for off-site disposal. On August 17, 1979, they submitted a summary of approaches for dealing with the site. This report and subsequent investigations by State officials led to their taking initial measures to stem the flow of contaminants from the site. Several hundred absorbent pillows were set out in October 1979 to prevent the leachate from spreading into the surrounding swamp, and the State drew up a bid proposal for the removal of the hazardous waste at the Picillo property.

300.68(e)(1)
initial remedial
measures

300.65(b)(7)
barriers to
deter spread
of release

In February 1980, two events occurred that made Federal cleanup money available for the emergency and subsequent remedial work at the Picillo site. The first was a State request for funds from Section 311(K) of the Clean Water Act. Following the request, the U.S. EPA's Region I OHM personnel began an information search and performed an initial sampling of the swamp area. In May 1980, soon after the Picillos were notified that enforcement action would be taken, the State was informed of their Section 311(K) request approval. The second event was a meeting at which EPA and RIDEM agreed on a project to be funded by EPA's Solid and Hazardous Waste Research Division to conduct geophysical testing and monitoring at the site. Consultants were engaged to perform a hazardous waste investigation, including sampling and analysis of all media.

300.67(b)
state request for
federal assitance

300.67(b)
data review

In March 1980, EPA formally became involved with the emergency action when they initiated a field study of the area and in April 1980, RIDEM's consultants presented their final project report indicating groundwater and surface water contamination at the site and worsened air quality near the swamp area due to contaminant volatilization. Following the report, EPA had their Emergency Response Team begin a full investigation of the area. Utilizing funds from the State's Hazardous Waste Management Act of 1978, the State hired a contractor to clean up the hazardous wastes at the Picillo site. On June 12, 1980, with EPA in charge of air and surface water monitoring and providing technical assistance as requested, the State-led cleanup project began.

300.68(e)(2)(iv)
environmental
effects and
welfare concerns

Although local citizen involvement appeared to have begun around July 1980 with the formation of an organization called "Save Our Waters" (SOW), citizen concern regarding pollution at the site had been expressed as early as 1977 when the site was initially discovered. During emergency action at the Picillo site (March 1980-April 1982) the local town officials, RIDEM, EPA Region I personnel, and local citizen groups tried to work in close coordination. Public meetings were held and area residents were briefed at citizen group meetings. The townspeople generally relied upon the Town Manager, designated as the local contact by the Town Council, for information about ongoing work at the site. The first community relations plan was drafted in October 1981 for the planned removal work at the Picillo site with the following objectives:

- Ensure a thorough understanding by citizens of the purpose and the method of the removal, along with the statutory requirements of Superfund funding
- Make public the progress made and the safety precautions taken at the site
- Solicit information and opinions from citizens concerning the site.

A great deal of time and effort had been taken to develop a community relations plan for the Picillo site, and following its inception, it was carried out dutifully and proved to be effective. However, over time, its effectiveness diminished considerably because of longlag times involved in disseminating available information. In 1984, the community relations plan was totally reworked and redesigned to eliminate inadequacies that had been identified. EPA met with townspeople and SOW representatives and checked, sorted, and verified citizen files of information about the site, as well as had an executive summary prepared to fully explain the present situation. This kept information flowing between EPA, the State, and the community. The latter plan, a joint EPA/RIDEM effort, proposed to accomplish the following:

- Draw people into the process, emphasizing a two-way flow of information
- Establish credibility of EPA and State personnel with the community
- Disseminate information coherently and efficiently
- Hold open house, including question and answer sessions.

Selection of Response Technology

The selection of response technologies at the Picillo Farm site did not proceed under the auspices of well-institutionalized Federal and State hazardous waste management programs. In 1977, when the Picillo Farm problem was identified, the national hazardous waste management program was only being developed. Consequently, investigative and remedial actions were taken one step at a time, without the structure of a well-exercised implementation plan to follow, and substantial funds were absorbed by the lagtime involved in decision-making. The following paragraphs describe the process by which the response actions implemented at the Picillo site were selected.

The initial actions taken at the site involved the removal of stored drums, most of which contained ferric chloride. The removal of these combustible materials was prompted by a series of actions taken by RIDEM and the court following a fire and explosion incident at the site in September 1977. Drums containing sodium aluminum hydride, a highly explosive material when in

300.65(a)(3)
risk of fire
or explosion

contact with water, remained onsite until an approved disposal facility was located. By July 1979, the stored drums containing these materials had also been completely removed from the site premises.

In August 1979, RIDEM contracted a consulting firm to conduct a preliminary field investigation and an engineering analysis of abatement alternatives. The following options were discussed in their Phase I report (April 1980):

300.68(h)
initial screening
of alternatives

- No action
- Site encapsulation
- Leachate collection and treatment
- Drum removal and disposal.

Cost estimates and conceptual designs were produced for the four abatement options, but a preferred long-term remedial plan could not be recommended because of the need for additional site-specific information. It became apparent to RIDEM after the completion of the Phase I study that the drums disposed of at the site had to be removed prior to implementing any plan to alleviate the groundwater contamination problem. Until this was done, the extent of groundwater contamination, uninfluenced by the continued existence of a source, could not be assessed and, consequently, the most cost-effective remedial alternative to abate the groundwater problem could not be selected. Thus, the report recommended the initiation of drum removal from the northeast trench as an initial emergency action since the preliminary investigation had confirmed this area to be a continuing source of contaminants.

300.68(g)
development of
alternatives

With the additional information gained from the Phase II investigation, the alternatives studied in Phase I were further evaluated. Descriptions of these alternatives and additional options examined in later studies are detailed in Table 5. This summary table also gives the rationale for either the acceptance or the rejection of each alternative.

TABLE 5. ABATEMENT ALTERNATIVES, PICILLO FARM, RHODE ISLAND

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
1. No Action[r]	No action alternative would have been advantageous only if (1) source of contamination was exhausted or (2) total mass of contaminants would volatilize in swamp, swamp remains totally isolated and Whitford Pond is unaffected.	• Does not remove source of pollutants. • Potential for future release of contaminants still exists. • Swamp not proven to be a treatment mechanism and not isolated.	
2. Site Encapsulation[r]	Construction of impermeable subsurface, barrier wall around source of contaminants. This option would control pollution at its source and would permit safer working conditions than drum excavation and removal.	• Success of containment required relatively impermeable bedrock to key into; in this case bedrock is fractured and would not act as a secure base. • Depth of bedrock would have incurred high cost. • Does not remove source of contaminants, i.e., potential for future release still exists. • Significant amount of source is in liquid state. • Requires continuous monitoring and maintenance, i.e., high O&M cost.	300.70(b)(1) (iii)(4) impermeable barriers.
3. Leachate Collection and Treatment[r]	Intercepter trenches constructed either adjacent to or downgradient of barrier wall controls pollution at its source. In conjunction with barrier wall construction, would permit safer working conditions than drum excavation and removal.	• Success of collection depends on condition of bedrock. In this case bedrock surface too irregular, would require several pumping stations. • Bedrock would not provide a secure, impermeable base. • Again depth of bedrock would incur high cost. • Does not remove source of contaminants. • Treatment system would not remove all contaminants from leachate. • Potentially high life-cycle cost.	300.70(b)(1) (iii)(C) groundwater pumping 300.70(b)(2) (ii)(B) chemical methods

(continued)

TABLE 5. (CONTINUED)

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
4. Drum Removal and Disposal[a] (in conjunction with continued monitoring of swamped plume)	Drum excavation, testing and segregation of contents, proper disposal of drums and contents (higher risk of injury to workers than other options).	• Significant source of chemicals remained within buried drums. • Source of contaminants removed. • Dispersion of contaminants in groundwater monitored.	300.70(c)(1)(ii) off-site transport
5. Detonation of Unidentified Materials[a]	Detonation conducted on pad covered with polyliner and clay layers; unidentified materials were exploded using high speed/high energy explosive charges; continuous air monitoring conducted during these operations.	• Lower cost and less risk than over-the-road transport and disposal option.	
6. Landfarming of Contaminated Soils[a]	Biodegradation of phenols (phenol soil pile) by inoculation of soil with microbes capable of degrading organics. Goal was to reduce phenol concentration to 99 ppm (mg/l) from existing 900 ppm (mg/l).	• Low cost in comparison to removal and off-site disposal options.	300.70(b)(2)(iii)(E) in site soil treatment
7. Drum Removal[r] and Disposal with Leachate Collection and Treatment*	Drum excavation testing and segregation of contents, disposal of drums and contents, coupled with leachate collection using pumping scheme, and on-site treatment.	• Uncertain of swamp's role as treatment mechanism. • Post-drum removal, groundwater monitoring necessary prior to decision regarding treatment option. • High cost of on-site treatment schemes.	300.70(c)(1)(ii) off-site transport 300.70(b)(1)(iii)(C) groundwater pumping 300.70(b)(2)(ii)(B) chemical methods
8. Plume Containment[r]	Encapsulation of contaminated groundwater plume by means of subsurface impermeable barrier coupled with impermeable cap.	• Source of waste not concentrated in limited area. • Bedrock will not act as secure, water tight base. • Great area/extent over which plume has spread.	300.70(b)(1)(iii)(A) impermeable barriers

*Rejected as alternative for immediate action; presently leachate collection/treatment phase being considered as long term option.

(continued)

TABLE 5. (CONTINUED)

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
9. Groundwater Recovery, Treatment and Discharge^u	Recovery: Installation of a number of strategically placed wells; 4 recovery schemes examined (below); (a) 3 recovery wells plus gravity system; intercept all groundwater with contaminant concentrations greater than 10,000 ppb; 3 recharge wells. (b) 7 wells plus gravity system; intercept all groundwater with contaminant concentrations greater than 1000 ppb; 3 recharge wells. (c) 8 wells, one of which is in bedrock; intercept groundwater contaminated within 100-1000 ppb; 3 recharge wells. (d) 10 wells; complete restoration of all groundwater to 100 ppb level; 3 recharge wells. Treatment: (a) Air stripping (b) Carbon adsorption (c) Biological (d) Chemical fixation/oxidation Discharge: Treated groundwater discharged back to system.	• Decision whether to recover or treat contaminated groundwater has not yet been made; awaiting completion of GCA feasibility study. • Recommended alternative consists of option (d) combined with air stripping and air emissions control by activated carbon with solvent recovery; all effluent through carbon adsorption.	300.70(b)(1)(iii)(C) groundwater pumping 300.70(b)(2)(ii)(c)(1) air stripping 300.70(b)(2)(ii)(c)(2) carbon adsorption
10. Long-term No-action^u	No further action taken at the site with respect to the contaminated groundwater issue.	Rationale for possible preference: • Contaminants migrate to swamp areas where they are adsorbed by soils, biodegraded and volatilized. • Site hydrology indicates very little contamination will find its way to Whitford Pond; surface water sampling results support this conclusion. • Contaminant migration by air route is minimal based on detected concentrations in past, which were far below TLV levels set to protect workers. • Groundwater in the site area is not a source of drinking water.	

Key

u - Undecided
r - Rejected
a - Accepted

Based on field investigations, evaluation of alternatives, and recommendations, the joint decision was made by RIDEM and EPA that the most cost-effective immediate action was to remove and to properly dispose of the drums and their contents. In sequence, the four trenches on-site would be excavated, the drums removed and categorized, and all hazardous materials disposed of at secure, off-site disposal facilities.

300.70(c)(I)(ii)
off-site transport

As site operations continued, however, two additional remedial technologies were selected for use at the Picillo site: (1) detonation of unidentified materials, and (2) landfarming of contaminated soils. During the remedial action, unidentified materials on-site were detonated because the costs and the risks involved in transporting these materials on public roadways were extremely high. After all other site remedial activities were completed, a landfarming technology was selected to reduce the phenol concentration of a soil pile left because of this technology's low cost compared to removal of off-site disposal options.

300.70(b)(2)(iii)
(E) in situ soil
treatment

Although the drum removal/disposal action was confidently selected, an additional cost-effectiveness study was conducted to recommend the optimal leachate collection and treatment option for the site. This study was conducted by another group under contract to RIDEM and completed in February 1982. In light of the additional knowledge regarding site hydrogeology and contaminant (drum removal and disposal from the northeast and northwest trenches), RIDEM wanted to reassess the available alternatives in order to most cost-effectively implement the final phase of cleanup activities (drum removal and disposal from south and west trenches). In addition to the four alternatives initially examined, the new study evaluated drum removal and disposal coupled with leachate collection and treatment (see Table 5). The recommendation made by the second contractor team was to continue with drum removal and disposal operations, since it was the least costly option and the most direct means of mitigating the immediate problem. The use of a leachate collection and treatment system was believed to be unnecessary at this stage of operations and was rejected as part of the immediate action plan at the site; however, at the time of this writing, it was being evaluated as a potential long-term option.

300.66(a)
assessment for
further action

Following the completion of removal operations, RIDEM believed the next necessary step was to clean up groundwater contamination at the site. Accordingly, RIDEM hired a new contractor team to conduct a remedial investigation/feasibility study of groundwater treatment alternatives. In June 1983, the contractor submitted their first draft of the assessment to EPA and the State. There were critical problems found with the draft report in that it was not in compliance with the National Contingency Plan (NCP); however, this could not have been foreseen. The administrative changes occurring within EPA at the time obscured changes being made regarding the NCP criteria and their relationship to the preparation of site closure feasibility studies.

The problems with the draft report were two-fold. First, the study was conducted under the unquestioned and unwarranted assumption that any groundwater contamination at Picillo was a risk to human health and the environment, and thus required treatment. In actuality, the contaminated groundwater at the Picillo site has since been found to pose no imminent threat to human health or to the environment. The groundwater is not used as a drinking water soruce, nor is it used for irrigation purposes. In addition, contaminants are migrating to swamp areas where they are being either biodegraded or volatilized. The odor in the unnamed swamp area is a problem, but poses no health hazard.

Second, the PCB-, phenol-, and organic-laden soil piles left on-site as a result of drum removal operations were not examined as part of the June 1983 feasibility study. This June study examined groundwater contamination in the vicinity of the Picillo site, but never looked at continuing on-site sources, assuming that the existing groundwater contamination in the site area was the major problem to be contended with.

The NCP, on the other hand, requires that a screening process and a site-specific risk assessment be undertaken during a feasibility study such that the necessary extent of response could be determined prior to the evaluation of alternatives. A revised feasibility study by the same contractor, which was in closer compliance with NCP criteria than the original, was completed in August 1983. However, the central focus of the revised feasibility study report, was still on groundwater treatment alternatives. EPA did not accept the revised feasibility study. Additional studies were required to meet NCP criteria and to provide the necessary information for the selection of any additional remedial work to be conducted at the site.

To meet the risk (endangerment) assessment criteria of the NCP, EPA used their Technical Enforcement Support (TES) contractor who had extensive expertise in this area to conduct this portion of the study. This study was initiated in the fall of 1983. At this time, the TES was also contracted to conduct an additional feasibility study to compliment the endangerment assessment study. The TES Environmental/Risk (Endangerment) Assessment report was completed in June 1984. With the completion of the second feasibility study in November 1984, a final decision will be reached concerning further action at the Picillo site. At the time of this writing, the second study had not been completed, and therefore, a final decision had not yet been made.

Extent of Response

The decisionmaking process regarding the selection of remedial actions at the Picillo site did not involve well-defined criteria for the extent to which the site would be cleaned up, i.e., there were no quantitative contaminant levels that had to be met. As previously discussed, the response actions at this site were taken one step at a time. The immediate and initial goal of the actions taken at the site was to eliminate the major source of contamination. Once this goal was met, the steps that would follow would depend upon the nature and the extent of residual contamination. At the time of this writing, decisions regarding the final extent of response at the site were pending completion of the feasibility study in November 1984.

300.68(j)
extent of
remedy

DESIGN AND EXECUTION OF SITE RESPONSE

The initial response at the Picillo site was taken by the Picillos in March 1978, pursuant to a court order. They removed 27 drums of various wastes, mostly ferric chloride, for disposal to an approved facility in Braintree, Massachusetts. Drums containing sodium aluminum hydride, a highly explosive substance when in contact with water, remained stored on-site at this time.

300.65(b)(6)
moving hazardous substances
off-site

During June 1978, RIDEM requested bids to clean up the site, and a State-approved disposal facility was sought for the explosive materials still on-site. No action on the bid request occurred for about one year, pending legal battles against the site owner. In May 1979, after unsuccessful litigation, it was shown that the Picillos were unable to take necessary remedial action to clean up their property. A decree was handed down from the Court, directing RIDEM to engage a company to remove the explosive materials from the site. In June 1979, the materials were repackaged into overpack drums to be ready for removal from the site when a disposal facility was located. In July 1979, under RIDEM's supervision, a group disposed of 14 drums of explosive material at a secure site outside of the State. It was at this point that RIDEM began the task of finding a qualified consultant to characterize the Picillo problem and to present alternatives for its remedy. On August 5, 1979, RIDEM hired a contractor to conduct a two-phased study involving a survey of site conditions and recommendations for abatement options. Upon the receipt of their final Phase I report in April 1980, RIDEM contracted with a prime contractor of Stoughton, Massachusetts to begin the excavation of the northeast trench.

300.68(c)
judicial
process

300.68(c)
evaluation of
cleanup proposals

Site preparation activities for this first phase of removal operations were not extensive. Site layout requirements were based on the consultant's estimate that there was a maximum of only 200 drums in the northeast trench. Three main areas were designated around the trench; (1) a bermed storage area, (2) a crushing area for empty drums, and (3) a stockpile area for solid materials. An office trailer, a decontamination area, and an eating area were also located on-site. Figure 7 gives a schematic view of the early layout of the site.

The excavation of the northeast trench began on June 12, 1980. The agency leading the site operations at this time was RIDEM. EPA assisted by monitoring air and surface water conditions in the area, and by providing technical assistance on-site, if requested.

300.68(b)
state remedial
action

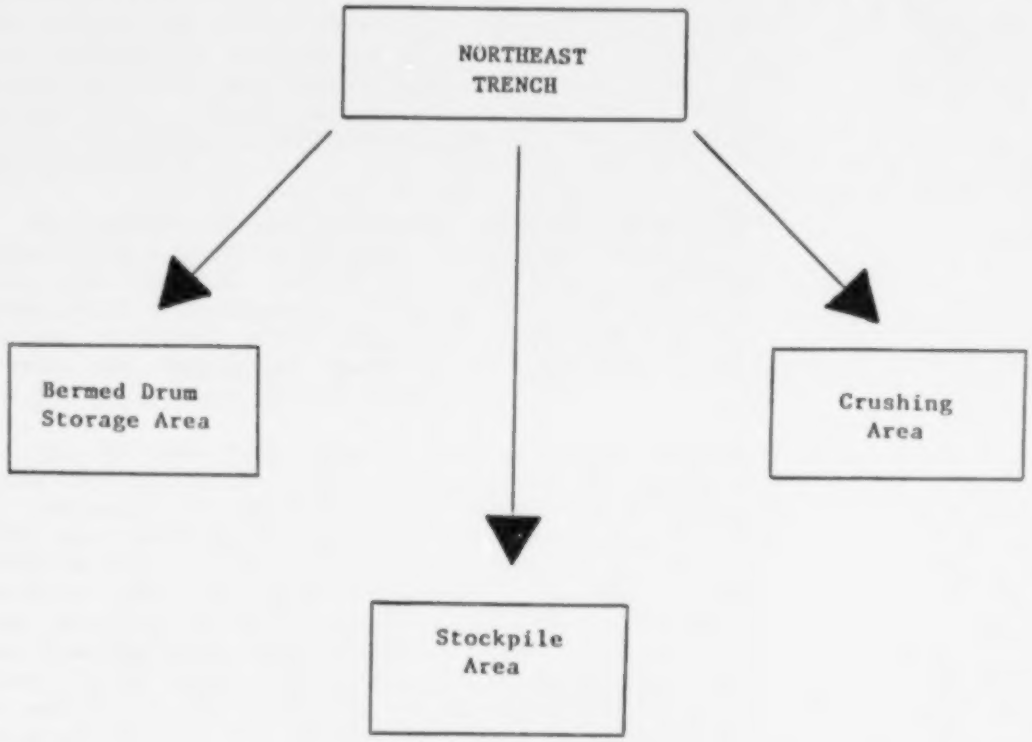

Figure 7. Conceptual Layout for the Northeast Trench Excavation Operations, Picillo Farm Site, Rhode Island

Three pieces of construction equipment were used during the northeast trench work. A backhoe was used in addition to the backhoe for drum removal and for transporting soil material that accumulated along the sides of the excavation trench.

As drums were removed from the trench, they were sent to the crushing area if they were empty or transported to the storage cell if they contained material. All other excavated material, e.g., contaminated soil, metal scraps, etc., were stockpiled. It was soon evident that there were more than 200 drums in the northeast trench. As excess drums were removed, the storage area reached its holding capacity. Drums were being stacked 40 drums deep and 8 drums wide in the original storage cell. There was no aisle space for walking through the area. Additional temporary storage cells were constructed.

One aspect of the operations that compounded the excessive drum problem was that sampling, drum segregation, and disposal actions were not being performed concurrently with removal. Classification of materials was not performed until after the drums had been excavated, and therefore, there was no organized system used for the storage of the containers.

One of the main reasons for continued problems during this first phase of operations was the design of the contract through which the work was performed. Since the contractor was paid per drum removed, his objective was to remove all of the drums as quickly as possible. The consequent carelessness in removing the drums resulted in a lot of material being allowed to leak from the drums into the trench area. Thus, a large volume (5,000 cubic yards; 3823 m^3) of contaminated soil was generated and stockpiled during this phase. Soil generated during the northeast trench excavation was subsequently analyzed and found to contain PCBs and other organic compounds. This soil was stockpiled in the southeast corner of the site and is referred to as the PCB soil pile.

Flammable liquids removed from the trench were consolidated in a 6,000-gallon tanker, with the intent of expediting later disposal operations and eliminating the cost of sampling individual drums. However, this action however, was later found to delay the disposal of 4,000 gallons of waste oil because of PCB contamination (1,500 ppm; mg/l). The tanker was stored on-site much longer than anticipated while arrangements for the disposal of its contents were made.

A large number of drums in the northeast trench were severely corroded and in a deteriorated and leaking condition. Consequently, high vapor levels and pools of liquid were continual problems. Working personnel used very limited safety, health, and decontamination protocols. Standard safety equipment used during this phase of work included Tyvek suits, full-face respirators, and fire extinguishers.

On June 24, 1980, RIDEM halted excavation activities (60 percent completed) in the northeast trench to reassess progress in light of remaining project funds and the unexpected number of drums. Based on their contractor's report, RIDEM had anticipated between 90 and 270 drums of hazardous materials; however, over 1,200 drums had been excavated at this point. On July 24, 1980, one month later, RIDEM resumed excavation of the northeast trench. EPA had agreed to assist in emergency containment efforts by providing temporary holding cells on-site, as well as by over-packing and transferring leaking drums.

300.67(b)
state request
for federal
assistance

On August 4, 1980, RIDEM stopped the excavation again. This time operations were halted because residents expressed concern at a town meeting that so much material stored above ground on-site would present safety hazards and possibly create another fire, as in 1977. The State initiated a disposal action, and on August 20, resumed excavation of the northeast trench.

Operations at the northeast trench were finally completed at the end of August 1980, with a final drum count of about 2,300. Waste disposal from the site began on September 15, 1980, following the completion of analysis of drum contents and bulk liquids by the disposal contractor. Disposal actions were undertaken during October 1980, at which time ten 10-ton truck loads of crushed drums were transferred to an approved disposal site in Niagara County, New York, and approxi-

300.66(c)(2)(ii)
assessing hazardous substances

300.65(b)(6)
moving hazardous
substances off-site

mately 160 drums containing acids, caustics, organic solvents, and waste oil were repackaged and shipped to an approved facility in Braintree, Massachusetts.

The final draft Phase II report, submitted to RIDEM at the end of October 1980, recommended the complete removal of all drums as the most cost-effective immediate action. Accordingly, in November 1980, RIDEM sought proposals from contractors for excavation and disposal of hazardous waste from the northwest trench. This trench was believed to contain between 8,000 and 12,000 drums of wastes plus free liquid. Early in December 1980, an agreement was struck between RIDEM and EPA regarding the operations to be conducted at the northwest trench. EPA agreed to contract and to monitor all of the tasks associated with the excavation using Section 311(K) funding, including ensuring on-site safety, identifying materials, constructing staging areas, overpacking and/or redrumming, command post security, utilities, and fences. RIDEM would fund the remaining activities associated with disposal. As a result of the change in each agency's responsibilities, the lead role at the site shifted from RIDEM to EPA. EPA was now responsible for the selection of a contractor to begin excavation of the northwest trench. In late December 1980, the same contractor who had worked on the northeast trench was hired by EPA to continue the work at the site in operations at the northwest trench. During this same period, EPA also arranged for the removal of the PCB-contaminated liquids still being stored on-site.

300.66(a)
assessment for
further action

Due to the problems encountered during the excavation operations at the northeast trench and the experience gained from this first phase of activities, much more care was taken in detailing the health and safety plan for site personnel, the decontamination protocols, and the excavation work plan. In particular, the site preparation activities undertaken by EPA were designed and engineered so that upon completion of the excavation of the northwest trench, excavation could proceed directly to the west and south trenches without further site preparation. The following activities begun on January 19, 1981, were performed during site preparation:

- Clearing and grubbing the area north of the northwest trench
- Constructing a staging area consisting of layers of clay and polyethylene
- Conducting a magnetic survey to delineate trench perimeters
- Establishing a command post equipped with telephone lines and radios
- Establishing site security
- Constructing temporary storage cells to contain 2,500 drums
- Establishing an on-site laboratory for waste analysis
- Constructing a safe entry/exit and working area for excavation operations
- Establishing a decontamination station.

Site preparations were just about completed by the week of March 13, 1981, with equipment mobilized to start on the following Monday, when EPA's On-Scene Coordinator (OSC) was notified to shut the job down due to insufficient funds. This notification had not come entirely as a surprise; the Section(K) funding mechanism had become less and less flexible, with money being allocated to the Picillo site on a week-to-week basis for over a month. In response to the unfortunate circumstances, the State notified EPA Region I that it intended to undertake and continue the excavation operation using the funds that were intended for use in the disposal phase. Agency responsibilities again shifted, and the lead at the site was once again taken by RIDEM. EPA's role during this phase of work was to maintain securities and utilities at the site, and to monitor State activities for possible creditable expenses incurred during this phase of Superfund activity.

On April 13, 1981, RIDEM initiated the excavation of the northwest trench. The site layout for the northwest trench excavation and the south and west trench operations that followed is presented in Figures 8 and 9. The excavation of the northwest trench was conducted using a backhoe and proceeded along the edge of a designated grid to a depth of about 12 feet (4 m) (Figure 10). Both a backhoe and a Caterpillar 215 then proceeded to remove soil and overburden along a line parallel to the trench axis, creating a cross-section as presented in Figure 11. Drums were removed layer by layer, the backhoe clearing away the overburden from each drum and loosening the drums when required.

A Caterpillar 215 grappler was then used to remove each drum from the trench. The grappler was perhaps the single most important addition to the northwest trench operation. Previously, the backhoe enhanced the rate of removal (from 20-30 to 100-150 drums per day), and minimized the risks of hazards to personnel safety in the removal area. The grappler put drum removal 40 feet (12 m) away from the operator and placed the removed drums into recovery drums without operators having to handle the drums directly.

If the removed drum was leaking, it was deposited directly into an overpack and then moved to a polylined short-term storage area. Leaking, deformed drums that would not fit in an overpack were placed temporarily in a nearby trough. Non-leaking drums were moved directly to the polylined storage area. All overpacks and drums with contents were then transported by backhoe to the staging area. Empty drums were taken directly to the crushing area. Contaminated soil was transported by frontend loaders and stockpiled. These procedures were repeated as each succeeding layer of drums was removed.

Similar conditions and problems existed with this trench as in the northeast trench. Most of the drums were in a fragile and deteriorated condition, and readily leaked into the trench when disturbed. On several occasions, a large number of drums ruptured simultaneously, creating large pools of chemical liquid in the trench. This type of leakage was quickly abated by overpacking the drums and vacuuming the free liquids from the trench using a "skid-vac" unit that had a

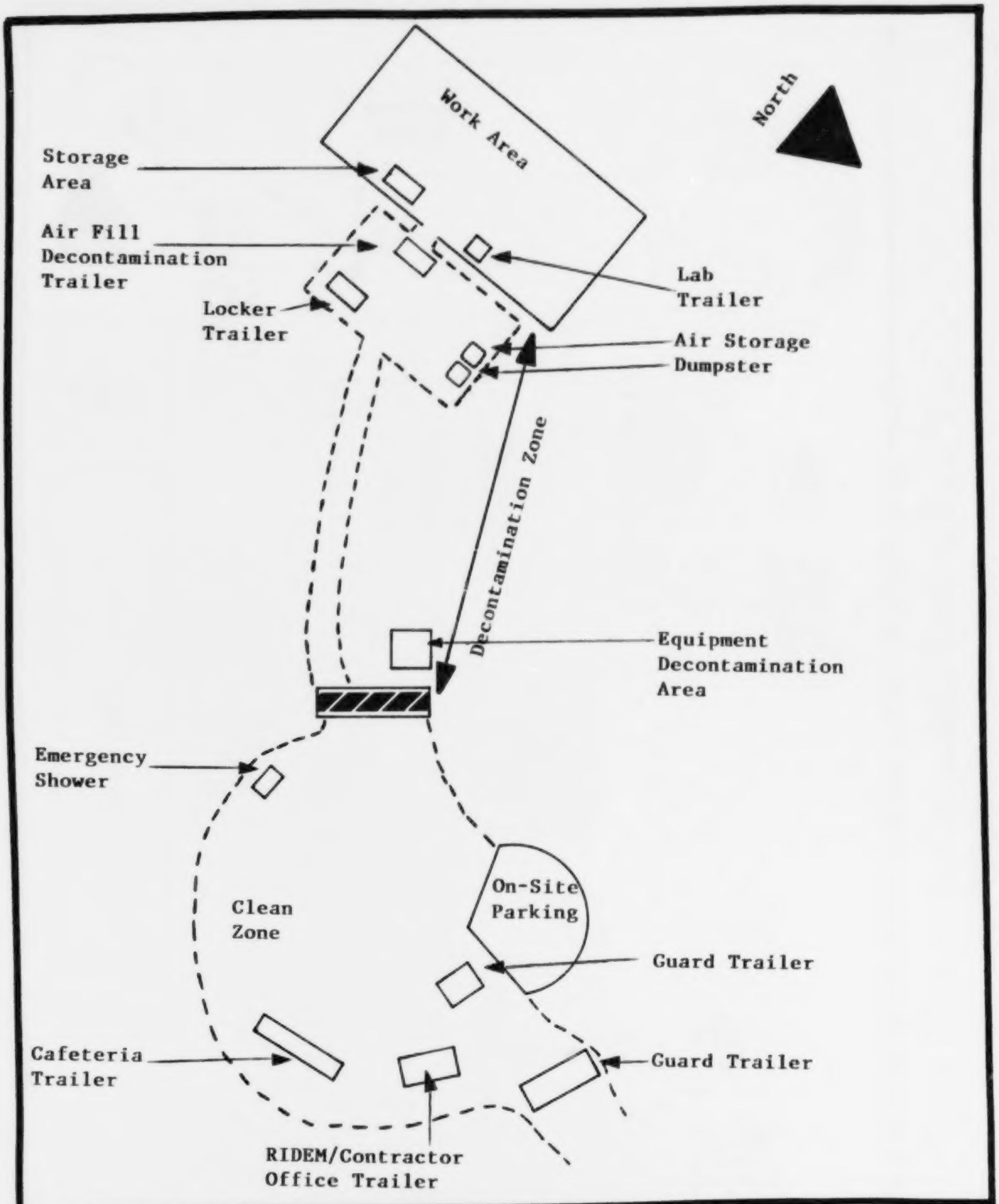

Figure 8. Site Layout for Excavation Operations at the Northwest, South and West Trenches, Picillo Farm, Coventry, Rhode Island

Source: RIDEM 1981

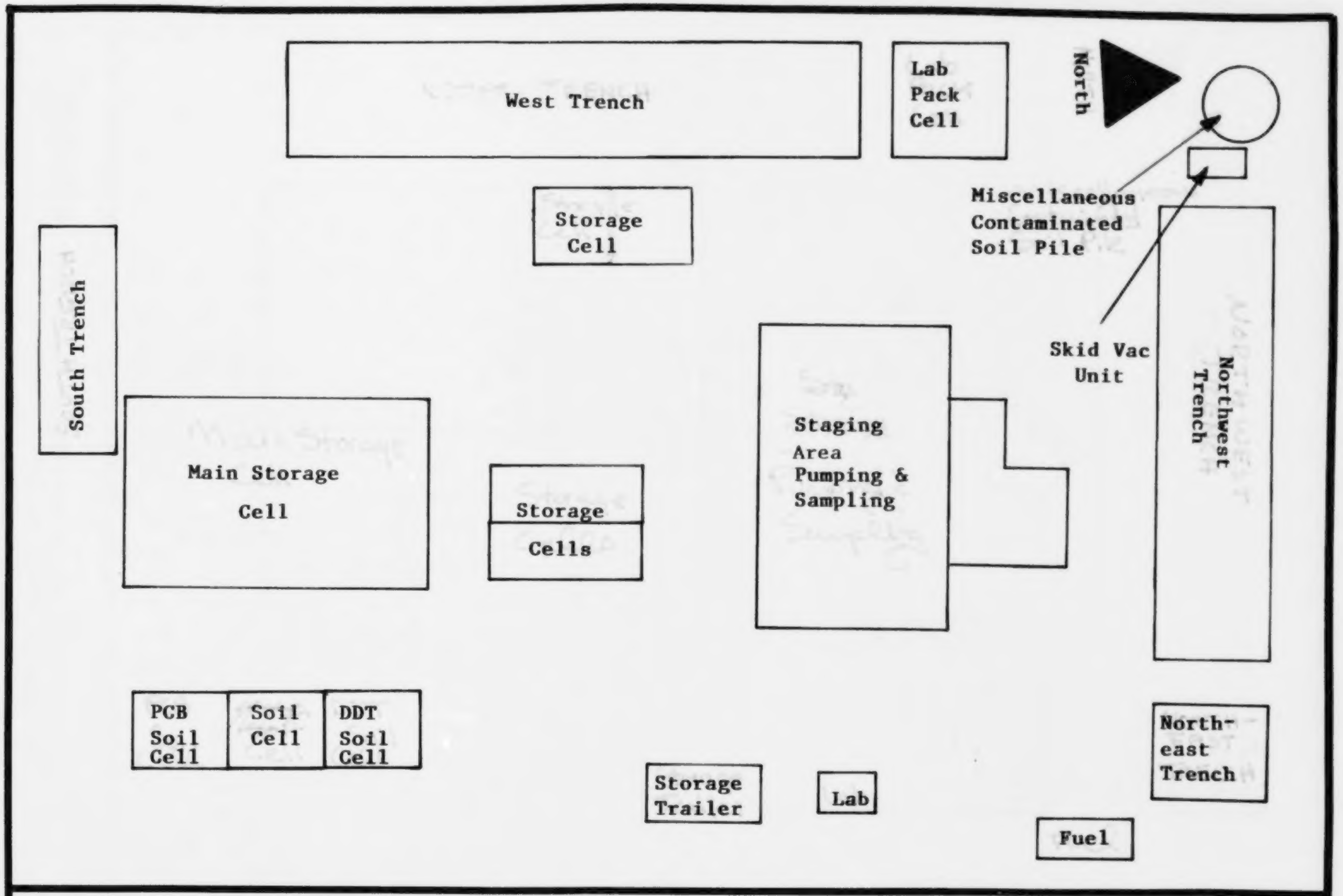

Figure 9. Work Area Details, Picillo Farm Site, Coventry, Rhode Island.

Source: RIDEM 1981

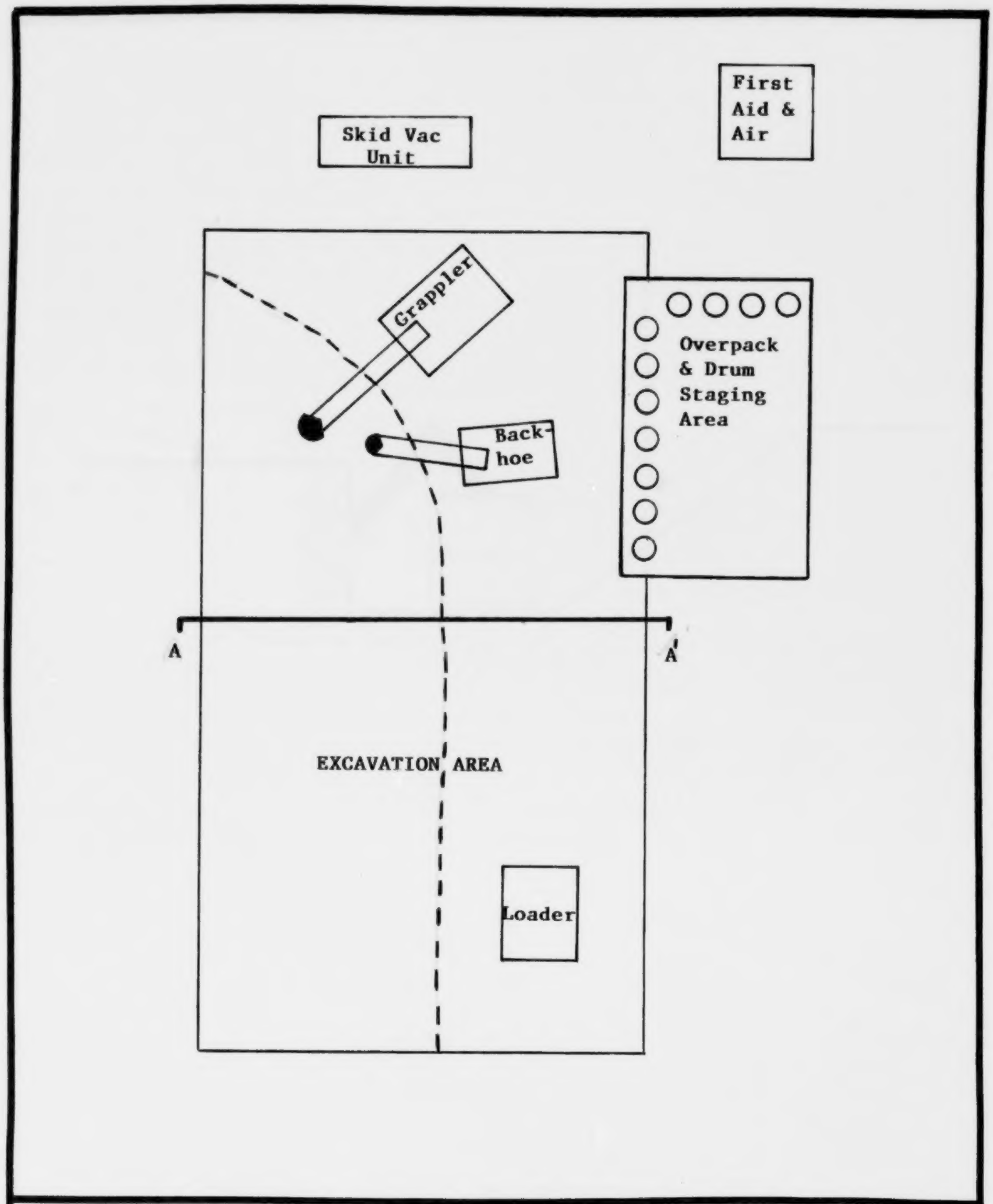

Figure 10. Excavation Operations at the Northwest Trench, Picillo Site, Coventry, Rhode Island

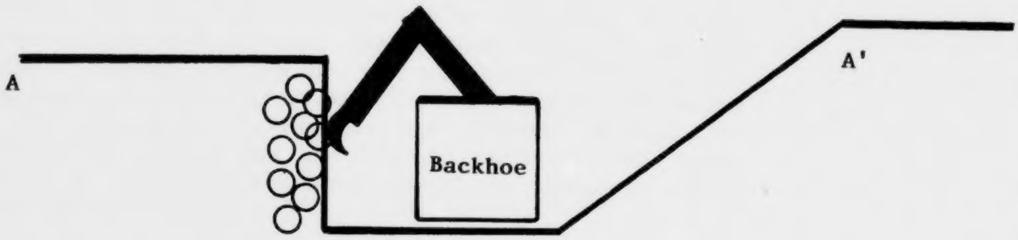

Figure 11. Northwest Excavation Operations - Drum Area Cross-Section, Picillo Farm Site, RI.

Source: RIDEM 1981

1,000-gallon (3,785 l) capacity and a 500-gallon (1,8931) holding tank. The use of soil as an absorbing media for such incidents, which was practiced during the northeast trench activities, had been abandoned in favor of the much more efficient vacuum.

The health and safety program designed for this second phase of work was much more effective than the one implemented during the northeast trench operation. Personnel working in the trench area, or "hot area," wore self-contained breathing apparatus. If a worker ever came in direct contact with a hazardous substance, numerous drums of water located around the site were available for washdown purposes. In addition, a fully equipped first-aid station was located adjacent to the trench. Safety monitoring was conducted continuously using explosimeters, cyanide detectors, oxygen detectors and OV analyzers. Finally, a hazard warning or notification system was established on-site that could produce an immediate response to alert personnel to a sudden safety hazard.

Drum storage again became a problem during the northwest trench operations because there was no ongoing simultaneous disposal action as had been originally planned. State funds that were going to be used for the disposal action were being used for excavation operations. As an excessive number of drums were removed from the trench, the storage cells reached their holding capacities and drums were placed in unlined leveled areas with only berms available for containment.

As drums were removed from the trench and handled according to their condition, they were then transported to the staging area (see Figure 8). Once a drum was delivered to this area, the staging personnel would determine whether it was necessary to transfer the contents to an overpack drum. When deemed necessary, contents were transferred by pumping the material into another container. The sampling crew would then collect samples of the contents. Each drum was then assigned a number; its size and whether it contained a solid or a liquid was listed in an inventory log. The samples were then delivered to the on-site lab and were analyzed for pH, flash point, cyanides, specific gravity, and water reactivity. From the on-site laboratory, the samples were then shipped to the off-site laboratory for disposal analyses.

Drums were classified as containing liquids, solids, lab packs, or acids, according to on-site laboratory analyses. When analyses were complete, a bobcat was used to transfer drums from the staging area to one of seven storage cells, depending on their classification, where they awaited analysis for disposal.

On June 12, 1981, the excavation of the northwest trench was completed. Approximately 4,350 drums and 5,000 gallons (18,925 l) of flammable liquid was removed for off-site disposal. On-site activities during the remainder of June 1981 involved stabilizing the site, securing the storage cells, and dismantling and decontaminating the mobile equipment on-site. Approximately 4,200 drums with contents and over 6,000 gallons (22,710 l) of miscellaneous liquids stored in tanks remained on-site at this time.

On July 7, 1981, an increase in funding was approved to begin disposal of drums. By the first week in August 1981, approximately 1,200 drums had been removed and disposed of off-site, leaving about 3,000 for which disposal action was still pending. The site was shut down from August 3-8, 1981, awaiting the receipt of analytical data from RIDEM. On August 18, 1981 after receiving the last composite analysis from the State, EPA began to stage and develop an inventory of drums on-site that would be removed. Representatives from industry were on-scene at the request of RIDEM to assist by identifying their products and by advising on the compatibility of these products. This assistance drastically cut down the number of "unknown" materials.

300.65(b)(6)
moving hazardous substances off-site

Unidentified materials, in particular, unidentified laboratory packs, created a significant problem during the preparation for disposal activities. Approximately 30 percent of the material remaining on-site fell into this category. A decision to open containers remotely had been made, but this and other attempted methods proved to be hazardous. After many unsuccessful attempts at alternative techniques, it was decided to build a pad and to detonate the unknowns.

The pad was constructed inside the northwest trench and consisted of a leveled area covered successively with a polyliner, a layer of clay, an additional polyliner, and another layer of clay on top.

Detonation activities, using a high speed/high energy military explosive charge known as "Flex-X," began on September 25, 1981. By using this technique, the materials being detonated were not being blown up into the air, rather they were being blown down into the sand pad. The Flex-X was placed on top of the subject material. This positioning, together with the high speed of the explosive, forced the material down into the sand. The detonations were performed by the Rhode Island Fire Marshall's Office and monitored by RIDEM and EPA personnel. After each detonation, air monitoring was conducted using a photoionization detector (HNU) and a portable gas chromatograph (Century OVA). After each day of detonations, the contaminated soil was collected and barreled for disposal and the pad was covered with plastic sheets to prevent any leaching. Detonation operations were completed on December 16, 1981. A total of 141 detonations were conducted, involving 739 containers.

Additional sampling and compatibility testing of the 2,579 drums remaining on-site continued through the first week of January 1982. When these activities were completed, the site was temporarily closed pending final disposal cost estimates and approvals. At this time, the following materials had been removed and disposed off-site:

- 22,000 gallons (83,270 l) of flammables and corrosive liquids (including leachate)
- 55 drums of PCB-contaminated materials
- 31 drums of flammable solvents
- 63 drums of waste acid
- 61 drums of repackaged laboratory pack materials.

Disposal of the 2,579 drums remaining on-site commenced on March 22, 1982. Due to the spring thaw, the access road and the roads on-site had to be upgraded to allow the tractor/trailer trucks access during the disposal activities. By April 6, 1982, EPA had removed 1,467 drums from the site for disposal. Responsibility for the remaining 1,112 drums on-site was transferred to RIDEM personnel. This terminated the EPA disposal action at the site under Emergency Response Action.

With Superfund monies, the State and its contractors completed disposal operations by the end of April 1982, and had begun excavation operations at the west and south trenches by May 7, 1982. By May 31, 1982, excavation of the west and south trenches was complete. Only 3,300 drums were removed, far less than the 8,500 expected. Disposal activities were ongoing during and after excavation had been completed. By July 10, all of the drums on-site had been removed and disposed of off-site at approved secure facilities. One PCB-contaminated soil pile (3,300 cubic yards; 2,523 m^3), one phenol-contaminated soil pile (1,700 cubic yards; 1,300 m^3) and one soil pile containing moderate concentrations of volatile organic compounds remained on-site. The third pile, known as the "Phase III" stockpile, was located in the vicinity of the staging areas used to hold damaged drums and other excavating debris.

The next action taken at the site by RIDEM was the treatment of the phenol pile using landfarming techniques. The phenol content of the soil was reduced through biodegradation by innoculating the soil with microbial aerobic heterotrophs, a type of microbe or bacteria capable of degrading organic contaminants. The treatment project began in August 1982. The goal of the project was to reduce the existing phenol concentration of 900 ppm (mg/l) to 99 ppm (mg/l) within 60 days of project commencement (OHM 1982; OHM 1983). This goal was surpassed with a final phenol concentration of 40 ppm (mg/l) (GCA 1984). This project concluded the emergency and remedial actions designed and executed at the site to date. At the time of this writing, a decision regarding further action was pending completion of the final feasibility study.

300.66(a)
assessment for
further action

COST AND FUNDING

Source of Funding

Throughout the response at the Picillo site, progress was interrupted repeatedly. The combination of funding source transitions, lead agency role changes, lapses in funding, and other problems resulted in an irregular chronology of site activities, and thus irregular funding.

During the 1980 emergency action at Picillo, State resources funded the northeast trench excavation and removal. After passage of the Hazardous Waste Management Act of 1978, $300,000 was made available to RIDEM. However, with an unexpectedly high number of drums found, the State requested EPA's financial assistance. The Clean Water Act Section 311(K) money was used by EPA to assist the State with emergency containment and to rebarrel leaking drums.

300.62(a)
state role

At the northwest trench, under a joint EPA/RIDEM effort, EPA took responsibility for selecting a contractor for on-site work and proceeded to spend Section 311(K) money for on-site preparation. The Section 311(K) fund was also expected to support EPA's contractor through excavation activities, but by March 1981, before excavation began and after numerous adjustments to the fund's ceiling, the Section 311(K) funds were exhausted. At this point, the State stepped in, bringing on their own contractor and utilizing a $1 million-State bond to begin excavating the northwest trench. Upon completion, the State's resources were just about depleted. The next step in the response effort disposal operations was supported solely with Federal finances and began after the last of State funds was used to provide EPA with sampling data.

In July 1981, after the Section 311(K) funds had been "thawed" or replenished, EPA received approval to use this money for off-site immediate emergency removal action on almost 1,500 drums containing flammable and other hazardous liquids.

September 14, 1981 marked the completion of emergency removal with Section 311(K) funds and the commencement of disposal actions at Picillo using Superfund emergency response money. Also implemented as response actions with these funds were:

300.61(c)
CERCLA financed
response

- Disposal of 124 lab packs
- Sampling and analyses of 2,600 drums containing solids on-site
- Compatibility testing of drum contents.

As in the case with the Section 311(K) monies, the Superfund emergency response ceiling was adjusted frequently, with the final figure extending over the $1 million designated limit.

The remaining actions at Picillo were supported with Superfund dollars from the February 1982 State/EPA Cooperative Agreement for planned remedial work at the site. Specifically, this encompassed:

- Disposal of the remaining drums on-site
- Excavation and disposal at the west and south trenches
- Treatment of contaminated soils
- An initial remedial investigation/feasibility study completed in August 1983 and a second remedial investigation/feasibility study, due in the fall of 1984
- All further studies, sampling, monitoring, and site security needed to continue during the cleanup effort at Picillo.

As of February 1984, approximately $2.5 million of the original $4,938,000 remained in the Cooperative Agreement, while most of the actions that were to be implemented with this money had been completed. As a result, EPA deobligated $2,439,771 of unexpended funds from the Picillo Hazardous Waste Site Cooperative Agreement. However, the State has the option of obtaining additional funding if it is determined that future remedial action is necessary.

Selection of Contractors

Contractors at Picillo were hired through competitive negotiations. There is a regular State procedure under which contractors are selected, which includes formal advertising and is based on an established, standardized list of qualifications and points of merits. This list includes demonstrated technical expertise, clarity of and organizational approach to project, cost-effectiveness and extent of reliability on subcontractor.

Mitre Corporation of Bedford, Massachusetts was chosen to evaluate remedial alternatives at Picillo in August 1979. Apparently, there were relatively few firms in the hazardous waste field at the time and Mitre was one of a few recommended by EPA. After a site inspection and interview, the company submitted a proposal that was acceptable by the previously mentioned standards.

The second contractor selected was Jetline Services, Inc. of Stoughton, Massachusetts. Several companies, at least six, bid on the project for the northeast trench excavation. Jetline's proposal was selected over the others on a fixed-cost basis, although a new contract had to be drawn up on a time- and-materials basis midway through excavation activities after the expected number of barrels was surpassed. EPA retained the services of Jetline for site preparation at the northwest trench. Their justification was that Jetline's proposed cost was low and that they were familiar with activities at the site.

In 1981, RIDEM brought on Peabody Clean Industries, Inc., of Davisville, Rhode Island, as the prime contractor for cleanup activities. They held an expertise with hazardous materials, had their own construction equipment and transportation equipment, had a low per diem total as an in-state contractor, and were familiar with the State's initial efforts at the site in 1979. After excavating the site, they continued with disposal operations, eliminating charges for demobilization and mobilization that would have incurred additional costs had a new contractor arrived.

On December 2, 1981, RIDEM sent invitations for submitting proposals to 12 firms who the Department knew to be experienced in hazardous waste cleanup. Out of the seven proposals they received, the selection committee--made up of representatives at the State, local, and civic levels--chose O.H. Materials of Findlay, Ohio to be the prime contractor for the excavation of the west and south trenches, and the disposal of the drums remaining on-site and those drums newly excavated. This phase of operations also included biodegradation of the phenol soil pile.

The remaining subcontractors, noted on the following page, were all selected through regular competitive bidding negotiations.

Subcontractors at Picillo Farm

GCA Corporation/Technology Division Inc. ----------------- Analytical Subcontractor

R.J. Corman Railroad Construction Co. -------------- Excavation Subcontractor

Environmental Waste Transporter --------------- Transportation Subcontractor

Colbert Security Company -------- Security Subcontractor
SCA/Recycling Industries -------- Disposal Subcontractor

Environmental Waste Recovery Inc. ------------------ Disposal Subcontractor

Cecos International Inc. -------- Disposal Subcontractor

Connecticut Treatment Corporation --------------------- Disposal Subcontractor

Chemical Waste Management ------- Disposal Subcontractor

Project Cost

The total cost for all removal actions and remedial work at the Picillo site at present is approximately \$4.96 million. This figure includes \$4.58 million for research and development, and capital and construction, of which about 85 percent was for excavation and disposal. A large part of this figure, approximately \$3.95 million, was a "one-time" only expense. Approximately \$380,000 was spent on operation and maintenance. Table 6 gives a summary of these costs, which are individually discussed next. As previously mentioned, the discussion here focuses only on the completed work at the Picillo site.

Table 6 covers the period between 1979 through part of 1984. All information is based on actual goods and services costs during that period and was drawn from various cumulative reports obtained at State and regional offices and from verbal communications with State and regional officials.

TABLE 6. PROJECT COST SUMMARY, PICILLO FARM, COVENTRY, RHODE ISLAND

TASK	QUANTITY	ESTIMATE	ACTUAL EXPENDITURE	UNIT COST	SOURCE OF FUNDING	PERIOD OF PERFORMANCE
I. CAPITAL COST AND R & D						
A. Pre-1980 Activity		N/A	$ 57,535.00		State	7/13/79-12/79
B. Remedial Investigation	--	--	$ 132,000.00	--	EPA/MERL R&D Grant	9/79-5/80
C. On-site Activity and Disposal	--	--	$	--	State	1977-1980
NE Trench - Phase I	2,254 barrels	--	$ 518,800.00	$225.00/barrel	State, 311(K)	
1. Excavation			($ 389,000.00)			6/12/80-8/26/80
2. Disposal			($ 129,800.00)			8/12/80-12/10/80
NW Trench - Phase II	4,350 barrels	--	$2,110,500.00	$469.00/barrel	State, 311(K), Superfund Emergency Response Money	
1. Excavation			($1,182,000.00)			4/6/81-6/12/81
2. Sampling			($ 174,000.00)			9/81-10/24/81
3. Disposal			($ 755,500.00)			9/81-1/82
West & South Trenches - Phase III	3,300 barrels	--	$1,325,000.00	$401.00/barrel	Superfund	4/17/82-7/16/82
1. Excavation			($ 666,000.00)			
2. Sampling			($ 127,000.00)			
3. Disposal			($ 532,000.00)			
D. Cost Effectiveness Analysis	--	$ 24,600.00	$ 24,600.00	--	Superfund	1/5/82-4/16/82
E. Treatment of Phenol Contaminated Soil	1,700 c.y.		$ 161,000.00		Superfund	9/82-12/82
F. Feasibility Study/ Remedial Investigation	--	$240,000.00	$ 247,000.00	--	Superfund	12/82-8/83
G. Community Relations	--	--	$ 5,000.00	--	Superfund	1982
CAPITAL AND R & D TOTAL			$4,581,434.00			
II. OPERATION AND MAINTENANCE						
C. Phase II						
Site security		$ 80,060.00			Superfund	1982
Monitoring (air, water)		$300,000.00				
* Estimates						
OPERATION AND MAINTENANCE TOTAL			$ 380,060.00			

Source: RIDEM 1984a; RIDEM 1984b; USEPA 1982

No individual monitoring costs were available for the first two trenches. Monitoring costs for all media in 1980 and 1981 by both EPA and RIDEM were incorporated into the total for other activities. However, for the south and west trenches, separate contractors were brought on for air and groundwater monitoring. The total for monitoring costs for the third phase was $300,000 (Table 6).

A. Pre-1980 Activity

1. Preliminary State-Financed Removal

In July 1979, RIDEM had Coastal Services, Inc. dispose of 14 barrels of sodium aluminum hydride. Service and labor costs were $11,473.69 including $209.38 to repackage drums containing pesticides. The remaining $1,200 was used to rent a trailer for barrel storage, bringing the total to $12,673.69.

2. Legal Fees

Approximately $44,860 was spent on legal fees in relation to the case, as well as on other actions to begin preparations for work at Picillo. These specific actions are unclear, but according to State records, began after January 1, 1978.

3. Remedial Investigation

A total of $132,000 was spent on a two-phased investigation of groundwater and surface water pollution at Picillo, which included the following projects:

Phase I

- Data review
- Metal detection and electrical resistivity surveys
- Installation of groundwater monitoring wells
- Sampling and analyses of all media
- Preliminary determination of site hydrology

- Preliminary engineering analysis of remedial work.

Phase II

- Bedrock sampling, installation of bedrock wells and field permeability testing
- Ground-penetrating radar survey
- Seismic refraction survey
- Continued sampling and analysis
- Recommendations for disposal options.

C. On-Site Activity and Disposal

The cost breakdown of on-site activities and disposal for the Picillo Farm site are shown in Table 7. The total cost for excavation, laboratory analyses, and disposal at the Picillo Farm site was $3,953,500. This total can be broken down by trench, beginning with $518,000 for the northeast trench in 1980. On-site activity costs were comparatively low at $389,000 because the original number of barrels expected to be removed was about 12 percent of the actual total. Virtually no laboratory work was performed, few supplies ($9,800) were purchased, and no formal safety plan had been developed, and consequently costs were low. Of the $120,000 incurred during disposal activities, approximately $41,000 was utilized for emergency containment and rebarreling leaking drums. The average cost per barrel for both excavation and removal was $225.

During the second phase of the response, the total cost of $2,110,500 for work at the northwest trench was significantly higher than Phase I, for a number of reasons. First, little site preparation took place during Phase I, while $234,000 was spent for Phase II site preparation, which included equipment mobilization, construction of a storage area, utilities, upgrading the access road, and providing fencing. The excavation cost for Phase II, $646,000, was higher because more drums were removed, and the total for on-site activity for the

TABLE 7. ON-SITE ACTIVITY AND DISPOSAL AT PICILLO FARM, COVENTRY, RHODE ISLAND

ACTIVITIES	NE TRENCH 1980 PHASE I	NW TRENCH 1981 PHASE II	W,S TRENCHES 1982 PHASE III
1. Mobilization/ Demobilization	$17,000	- -	$54,000
2. Site Preparation	$18,000	$234,000	$49,000
3. Excavation (Includes labor per diem and subcontractor costs)	$354,000	$646,000	$563,000
4. Disposal Preparation	-	$401,000	-
5. Subtotal 1 -- On-Site Activity	$389,000	$1,182,000	$666,000
6. Laboratory Analysis	-	$134,000	$112,000
7. Other Disposal Activity	-	$40,000	$15,000
8. Subtotal 2 -- Laboratory Work	N/A	$174,000	$127,000
9. Expendables/Supplies	$9,800	$180,000	$93,000
10. Disposal	$120,000	$475,500	$439,00
TOTAL	$518,800	$2,110,500	$1,325,000
11. Barrels Excavated	2,300	4,500	3,300
12. Cost Per Barrel	$225.00	$469.00	$401.00

Source: DEP 1984b

northwest trench, $1,182,000, was higher because of $401,000 incurred in preparation for disposal activities. The extensive laboratory analyses performed at an off-site laboratory cost $174,000 during Phase II activities. Finally, supply costs at $180,000 were high because equipment was actually purchased and, with a formal safety plan drafted, every possible safety precaution was taken. The total disposal cost includes $180,725 for an emergency disposal of 1,467 drums containing hazardous materials. The average cost per barrel for removal and disposal at the northwest trench was $469.

The last column in Table 7 is the total for work at the west and south trenches (Phase III), reading at $1,325,000. On-site activity cost $666,000, just over half of the total at the northwest trench. The laboratory analyses performed were on-site, included soil testing, and cost $127,000. Supplies and expendables amounted to $93,000 and disposal of 3,300 barrels cost $439,000 for an average per barrel expense of $401.

D. Cost-Effectiveness Analysis

Work on the last south and west trenches began after Perkins Jordan submitted a cost-effectiveness analysis of the planned remedial response. They received $24,600 for preparing the report.

E. Biodegradation of Phenol Pile

The total cost for landfarming 1,700 cubic yards (1,299 m^3) of phenol-contaminated soil was $161,000, or approximately $95 per cubic yard. This included construction of an under drain and liner system currently in place.

F. Remedial Investigation/Feasibility Study

The total for the first remedial investigation/feasibility study was $247,000. This included $73,555.96 for the services of the prime contractor, Tighe and Bond; $92,942.25 for their subcontractor, Leggette, Brashears and Graham, Inc., to provide a cost study for a groundwater recovery system; and $51,985.06 for their other subcontractor, Ecological Analysts, Inc., to report on groundwater analyses and human health effects. The total of $247,000 also includes an additional $28,500 spent by all three consultants in reevaluating, modifying, and completing the final report after additional work was recommended to upgrade it to EPA standards (DEM 1984b).

PERFORMANCE EVALUATION

The most recent groundwater, surface water, and air sampling and analysis effort completed at the Picillo site was during the summer of 1982. At the time of this writing, no monitoring data had been collected for evaluation since removal and disposal actions were completed at the site. However, such an effort will be initiated during the fall of 1984 until analyses data are available from samples collected since remedial work has been completed, an assessment of the effectiveness of the actions in reducing contaminant levels cannot be made. This section instead evaluates the implementation of response actions at the site, giving a brief description of the most critical problems and successes of the response program.

The implementation of response actions at the Picillo site was most affected by (1) lapses in availability of funding and delays in obtaining funding allocations, (2) contract limitations, and (3) community relations. The first two of these three issues were major programmatic encumbrances that resulted in prolonged delays, an untimely sequence of actions, and higher overall costs.

The most significant delay, and therefore the least cost-effective portion of the entire cleanup, is considered to be EPA's disposal action initiated after the excavation of the northwest trench. The initial delay of the disposal operation was caused by the slow transition from Section 311(K) monies to the CERCLA funding mechanism. Implementation of CERCLA legislation required categorization of the ongoing Section 311(K) funded cleanup as a planned removal action. However, a planned removal contract still had not been awarded when Section 311(K) funding lapsed during the summer of 1981. By September 1981, disposal actions had still not been taken, the drums had deteriorated significantly, and the On-Scene Coordinator judged the drums to be an imminent threat. An emergency contract was evenutally let to stabilize the site, and was subsequently utilized out of necessity as a sole available funding mechanism to complete the removal and the disposal of wastes then stored on-site. This situation caused much consternation on the part of the On-Scene Coordinator and the contractor in working under unnecessary contract limitations and vagaries, and resulted in numerous misunderstandings regarding allowable costs.

Another situation in which contract limitations hindered progress and increased costs was during the excavation of the northeast trench. The original fixed price contract employed by the State was not appropriate in the Picillo case because of the many unknowns associated with the site work. The fixed price contract did not provide the flexibility needed for the development of alternate actions when unanticipated conditions were encountered at the site. In addition, the on-site representative should have the authority to judge the effectiveness of alternate actions. The eventual change of the Picillo contract mechanism to a time-and-materials basis had a pronounced effect on the excavation of the remaining trenches. Consequently, excavation was accomplished in a much more cost-effective manner.

The funding and contract issues affected the overall chronology of on-site activities at the Picillo Farm. As a result, the chronology was more often dictated by programmatic considerations rather than by engineering judgment, and also caused significant delays and higher costs. Perhaps the most untimely action taken at the site was the drum sampling and analysis effort during the winter of 1981-82. Obtaining representative samples from 2,000 drums during freezing and sub-freezing temperatures, an extremely inefficient process at the least, was proven to be impossible by confirmatory sampling/analyses during warmer weather. Consequently, much costly duplication was required in re-sampling and re-analysis during the following spring. In addition to delays caused by winter weather conditions, the detonation of unknown materials caused another six-week delay. During the period that munitions were being used, other disposal activities were halted.

The third issue that most affected the implementation of response actions at the Picillo site was the involvement of the Coventry community and the community relations plan that was formed to facilitate the flow of information between the community and the site representatives. It was not until four years after the fire and explosion of 1977 that site activities finally commenced, and at this point the community was very tense, frustrated, and skeptical about the government's willingness to address the problem. To ease the anxiety and the tension that had developed over the years, the community and the site representatives decided that a community relations work plan would be developed and followed.

Once the Picillo community relations plan was in effect and information was flowing between the involved parties, the advantages of such a system became apparent in the way the community's attitude changed toward the site representatives. The community no longer felt isolated from the activities taking place on-site, and explanations for delays in schedule caused the community to refrain from holding any one group of people responsible for schedule problems related to the completion of site activities.

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ROSE PARK SLUDGE PIT
SALT LAKE CITY, UTAH

INTRODUCTION

NCP References

The Rose Park Sludge Pit is a waste disposal site located on 5-6 acres (2.0-2.4 ha) of a 33-acre (13.4-ha) public park in the Rose Park subdivision in northwest Salt Lake City (population 150,000). It lies between an industrial area on the north and a residential area on the south, and is bounded by an interstate highway (I-15) on the east and Boy Scout Drive on the west (Figures 1 and 2).

From the 1920's until the mid-1950's, acid sludges from petroleum refinery operations at the Utah Oil Refining Company (later purchased by Amoco Oil Company) were discarded in unlined pits and subsequently covered with lime and soil. Salt Lake City purchased the land in 1957 in response to years of residents' complaints against the dumping, and covered it with a soil cap in 1960. Residents became very concerned in 1976 when a bulldozer being used for the expansion of the recreational facilities at the park broke the overburden cap. Construction activities at the site and the passage of heavy equipment over the pit induced extrusion of the sludge at the surface. Construction workers in the vicinity of the pit reported respiratory and eye irritation and headaches due to fumes emanating from the sludge. The Salt Lake City/County Health Department initially responded to workers' complaints by analyzing samples of the sludge and recommending respirators for all workers in the area.

300.68(e)(2)(i) (A) population at risk

Analysis of the sludge revealed that it was an acidic black tar that released a sulfuric acid mist when agitated or when weather conditions with high

300.64 preliminary assessment

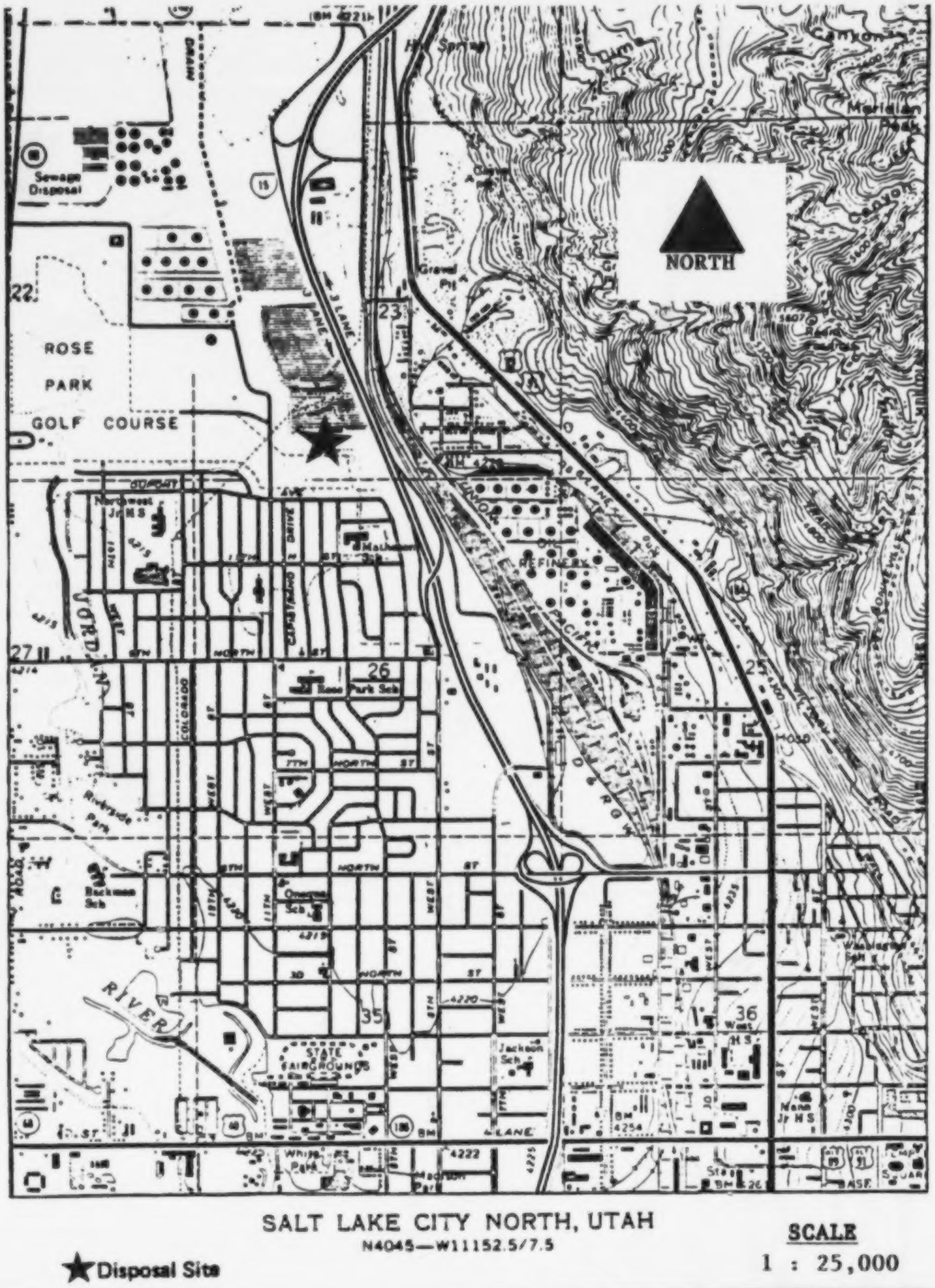


Figure 1. Topographic Map Showing Location of the Rose Park Sludge Pit , Salt Lake City, Utah

Source: Fred C. Hart Associates 1982

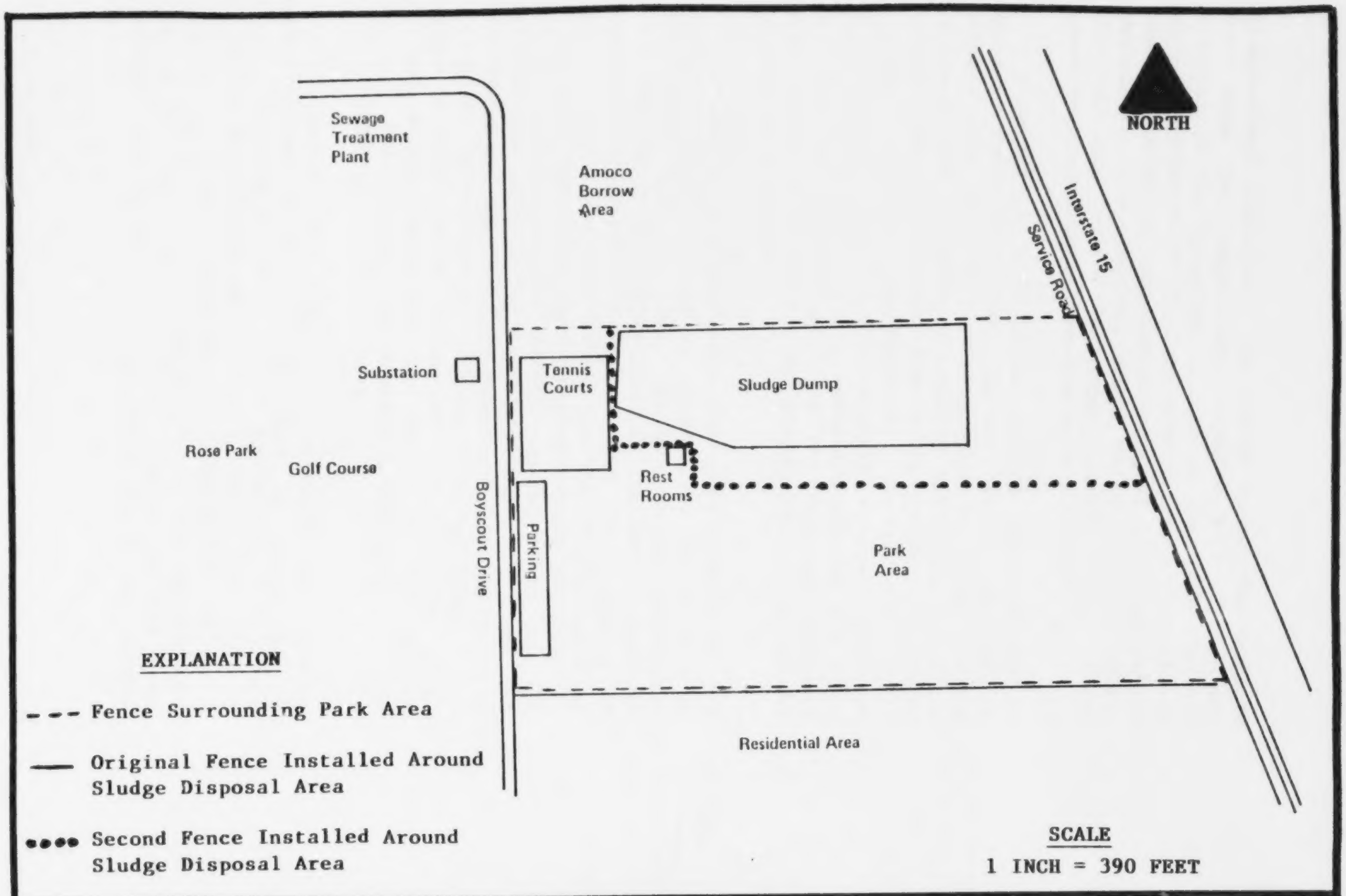


Figure 2. Rose Park Sludge Pit and Surroundings, Salt Lake City, Utah

temperatures prevailed. The sludge became semi-soft on days when the temperature exceeded 90°F (32°C) and resulted in the formation of pits on the surface of the site. Neighborhood children rode bicycles through the leaking sludge, in addition to using it to deface public restrooms. In addition, there was a ballpark nearby that was used for Little League baseball games. These games were attended by numerous area residents.

A series of field investigations was conducted by Environmental Protection Agency (EPA) contractors between 1979 and 1981. The results of these surveys indicated that a number of priority pollutants and other contaminants of concern (including xylene, dichlorobenzene, pyrene, phenanthrene, anthracene, lead, chromium, and arsenic) were present at low concentrations in groundwater in the immediate area of the site, but that the contaminants had not migrated appreciably. Analysis of ambient air showed low concentrations of volatile organics.

Community concerns over the pit focused on the physical contact with sludge extrusions, the release of acid vapors from the site, the groundwater contamination, and the potential decline in the area's property values. The community's concern over the proximity of the pit to the Matheson School and the children playing in the area was the primary force effecting the remedial action. The risk of direct contamination to the children was high. The community organized itself in the 1960's and was ready to exert pressure on the city and Amoco in order to address this problem. The community participated in most of the crucial meetings and had strong input into the design of the remedial action. For example, the community demanded that the park be restored for future uses.

300.68(e)(2)(iv)
environmental
effects and well-fare concerns

In March 1981, Amoco volunteered to provide technical and financial assistance to clean up the site. In August 1981, Amoco drilled boreholes and installed groundwater monitoring wells. The reported results of Amoco's analysis of groundwater and soil samples showed no priority pollutants in groundwater samples (in contrast to earlier studies by EPA contractors) and no migration of waste beyond the sludge pit.

Following the completion of the field studies, the Rose Park site was ranked for the National Priorities List using the hazard ranking model.

Although the site was not ranked high on the National Priorities List, it was selected as Utah's top priority site due to the potential for direct contact with the wastes. Amoco, City and State officials, and the EPA subsequently signed an Intergovernmental/Corporate Cooperation Agreement, whereby Amoco agreed to install a slurry wall and a clay cap containment system. The containment system has been completed and EPA is preparing to propose that Rose Park be placed in the deletion category of the National Priorities List.

Background

Beginning in the 1920's until the mid-1950's, waste acid sludges from the acid treatment of light petroleum oil products and other refinery wastes from the Utah Oil Refining Company's refinery operations were deposited in a pit. The oil sludge was intermittently covered with a thin layer of lime and soil, but the components were not mixed. Occasionally, other waste materials, such as construction debris, were deposited with the sludge in the pit. Disposal activities began before housing in the area was developed. Waste disposal at the site continued until the mid-1950's, when Rose Park residents demanded that City officials purchase the site so that waste disposal would cease. After Salt Lake City purchased the site in 1957, an estimated 100 to 200 truckloads of sludge were excavated and transported from the site for disposal. Approximately 50 truckloads were taken to the Salt Lake City airport to be used as sub-paving material. However, the sludge was too viscous for this purpose, and it was subsequently disposed of at the airport dump. An estimated 40 to 100 truckloads were transported to a dump reportedly at 6200 W on North Temple. When dump managers at North Temple refused to accept further amounts of the sludge, the City covered an unknown amount of the remaining sludge with soil at the site. The site property was included in the land used for the development of Rose Park Golf Course.

Although citizens continued to complain, the sludge pit did not receive a great deal of attention from the environmental regulatory authorities again until 1976, during the expansion of park facilities adjacent to the

300.63(a)(4)
discovery

Rose Park Golf Course. Plans to build a Little League ballfield and tennis courts were stymied when a bulldozer which was shaving the soil of the overburden cap broke through the caps. Passage of heavy machinery over the sludge pit caused many extrusions of the sludge. Once a bulldozer, that was working on the pit got stuck and started sinking into the tarry sludge.

The effusion of sludge produced pulmonary and eye irritation and headaches in workers in the vicinity of the pit. Later testing by the Salt Lake City/County Health Department showed that the sludge was acidic, with a pH of less than 1, and with concentrations of acid in the air ranging from 0 mg/m^3 outside the pit to 46 mg/m^3 inside the pit. (Note: The limit for occupational exposure in an 8-hour day for sulfuric acid is 1 mg/m^3).

300.68(e)(2)(i)
(C) hazardous
properties of
substances

In late 1976, the sludge pit was enclosed with a 4-foot (1.2-m) fence and signs were posted to limit access. Extrusions from the pit later appeared both inside and outside of the chain-link fence. Children were known to play in the tarry sludge despite the posted signs; they used the sludge to deface public restrooms located at the park.

At the request of Salt Lake City, the Utah Geological and Mineral Survey (UGMS) began a preliminary investigation in late 1977 to determine whether groundwater contamination was occurring at the site. The UGMS study concluded that industrial activities and possibly the disposal site seemed to be contributing oil and grease contamination to the groundwater downgradient from the site.

300.64(a)
preliminary
assessment

300.68(e)(3)(i)
water pollution

In July 1979, the EPA became involved with the site when the Region VIII Technical Assistance Panel's contractor was called upon to determine the extent of contamination. Initial chemical analyses of the sludge samples indicated the presence of various priority pollutants, including xylene, o-dichlorobenzene, and the weak mutagen and suspected oncogens: pyrene, fluoranthene and phenanthrene. Subsequent analysis of soil and groundwater samples for xylene and o-dichlorobenzene (selected as indicator compounds) showed that these substances were present only in areas immediately east and south of the site. This suggested that the sludge boundaries extended beyond the fenced area. The fence was then extended to include this area (see Figure 2).

300.63(a)(2)
government
investigation

The results of this survey sparked increased concern over the site and additional surveys were conducted by EPA's Field Investigation Team (FIT) contractor in August 1980 and May-June 1981. The results of these surveys showed the presence of low concentrations of a number of priority pollutants and other contaminants in groundwater collected from boreholes in the immediate area of the pit. Pyrene, phenanthrene, and anthracene were found at maximum concentrations of 1 to 3.5 ppm (mg/l) and naphthalene and fluoranthene were found in the 1-3 ppm (mg/l) range. Inorganic analysis showed elevated concentrations of lead, arsenic, copper, zinc, chromium, and barium.

300.68(e)(2)(ii)
extent of substance migration

The potential for future migration of contaminants in groundwater was considered to be low. This was attributed to the low permeability of the silty clay soils and to the nature of the tarry sludge itself. Furthermore, the shallow aquifer underlying the Rose Park site is not used for drinking water or for agricultural purposes due to the high salt content, and this further reduced the threat to public health.

300.68(e)(2)(i)
(A) population at risk

The most critical concern of the community, and the concern which eventually put this site on the National Priorities List as Utah's number 1 site, was the site's direct contact to park users.

Community involvement concerning the sludge pit and other industrial wastes in the Rose Park area was, according to local officials and citizens, the primary motivating factor in the cleanup of the site. Amoco's actions, as well as those of City, State, and Federal agencies, were directed towards alleviating fears within the community of the potential health hazard.

During October through November 1980, geophysical surveys were conducted to determine whether any additional sludge pockets extended beyond the fenced area. This was found to be the case. Because of the presence of the sludge pockets and since the existing fence and signs did not adequately segregate the sludge from park users, EPA requested additional fencing and warning signs. A 6-foot (1.8-m) high chain-link fence with a barbed wire top rail was installed and new warning signs were posted.

Prior to the enactment of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), a request for legal action against a potentially liable party came to the attention of the EPA enforcement division through a memo sent by the Director of the Air & Hazardous Materials Section, EPA Region VIII. Enforcement actions under Section 7003 of the Resource Conservation and Recovery Act (RCRA) were being considered because of the presence of hazardous material, the potential for migration and the maladies experienced by construction workers at the site.

In January 1981, after the enactment of Superfund, the mayor's office of Salt Lake City contacted the EPA to discuss the application of Superfund to the Rose Park Sludge Pit. Soon after the mayor's discussion with EPA, Amoco Oil Company (a party whose partial liability has been recognized), volunteered to take action at the site. Amoco initiated a comprehensive field investigation, signed an Intergovernmental/Corporation Cooperation Agreement (ICCA), and agreed to implement the remedial action. Amoco's site investigation began in August 1981 and included the drilling of boreholes and the installation of groundwater monitoring wells. Groundwater monitoring wells were subsequently sampled by Amoco and EPA's FIT and soils were sampled by Amoco alone. The results of Amoco's analysis showed that contaminants were not migrating in either soils or groundwater and that no priority pollutants were present in groundwater samples. The FIT sample analyses results differed from those of Amoco in that they indicated trace levels of a few priority pollutants in groundwater samples.

300.64(a)(3)
determination
of party's
willingness
to cleanup

Synopsis of Site Response

Six groundwater monitoring wells were installed around the site in August 1981. Four additional multiple depth wells were installed in May 1982. According to the ICCA, all 10 wells were to be sampled quarterly for the first year of monitoring and 6 of the 10 wells were to be sampled quarterly thereafter.

A circumferential slurry wall, completed on January 17, 1983, was used as a containment measure to prevent migration of the sludge from the pit. The slurry was keyed into an underlying low permeability layer to a depth of approximately 30 feet (9.1 m).

300.70(b)(1)(iii)
(A)(1)
slurry walls

A sand lens and a fabric membrane were placed over the sludge by July 2, 1983. The sand lens, used in conjunction with a carbon filter gas vent, was designed to collect and exhaust gases emanating from the pit. The fabric membrane, a relatively impervious geotextile material, was used to preclude upward migration of the sludge.

300.70(b)(1)(ii)
(A) surface seal

A clay layer 24 inches (61 cm) thick was placed over the membrane during July 1982 to prevent infiltration of precipitation and runoff. This was covered with 8 inches (20 cm) of topsoil for later planting of a vegetative cover of grasses.

300.70(b)(1)(ii)
(D) revegetation

The project was completed with the installation of a traffic barrier to prevent vehicular degradation of the cap, erection of new warning signs, and the planting of grasses. Planting of ground cover in the form of native grasses that would require little care was completed in the spring of 1984.

SITE DESCRIPTION

Surface Characteristics

The Rose Park Sludge Pit occupies a 5- to 6-acre (2.0- to 2.4-ha) area in Rose Park, a 33-acre (13.4-ha) city owned park located in the northwestern part of Salt Lake City. The area is largely industrial to the immediate north and east and residential to the south. As shown in Figure 1, it is bounded on the north by an Amoco borrow area, on the West by Boy Scout Drive and the Rose Park Golf course, on the south by Dupont Road and a residential area, and on the east by a sevice road and Interstate 15. The latitude is 40° 47' 57" and the longitude is 111° 55' 22". Another important feature in the immediate area is a series of buried drains and canals that were reportedly used to carry storm water, warm sulfur water, wastes from the Union Pacific Railroad shop, water from an ice loading plant, wastes from the Utah Oil Refining Company and, in emergencies, sanitary sewage prior to the early 1950's. These drains and canals will be further discussed later in this report.

300.68(c)(2)(i)(A)
population at risk

The Rose Park site lies within the Jordan River Valley, which is approximately 400 square miles (1036 km^2) and bounded by mountain ranges on the northeast,

east, south, and west and on the northwest by the Great Salt Lake. The valley has two major sources of surface water: (1) the Jordan River, which enters the valley through a water gap in the mountains to the south, flows northwest through the Farmington Bay Water Fowl Management Area, and empties into the Great Salt Lake; and (2) eight creeks, which enter the valley from the Wasatch Mountain Range to the East. The Jordan Range is approximately 0.75 miles (1.2 km) west of the site and groundwater in the project area is within the recharge area of the Jordan River. The river is not suitable as a municipal drinking water source.

The climate in the area of the Rose Park site is semi-arid with moderately cold to cold winters and hot summers. The mean annual precipitation in the Valley over a 39-year period between 1936 and 1975 was 15.63 inches (39.70 cm). The mean monthly temperature over the same period ranged between 19.8 and 91.1°F (-6.8-32.8°C). The mean monthly evaporation rate over a period between 1957 to 1968 ranged from less than 1 inch (2.54 cm) in December to 12 inches (30.5 cm) in July. Wind direction is south-southeast to southeast with an average speed of 8.7 miles per hour (14.0 km per hour).

300.68(e)(2)(i)
(E) climate

Within the Jordan River Valley, sand and gravel have been laid down irregularly as stream, lake, or delta deposits, probably since tertiary times. The valley, in late geologic times, was occupied by Lake Bonneville, Pleistocene predecessor of the Great Salt Lake. These physiographic conditions largely explain the topography, soils, and geology around the Rose Park area. The site lies within the broad valley which is underlain by almost flat (less than 1 percent slope) unconsolidated sediments, whereas the borders of the valley are marked by a unique series of terraces that characterize the shorelines of the old lake.

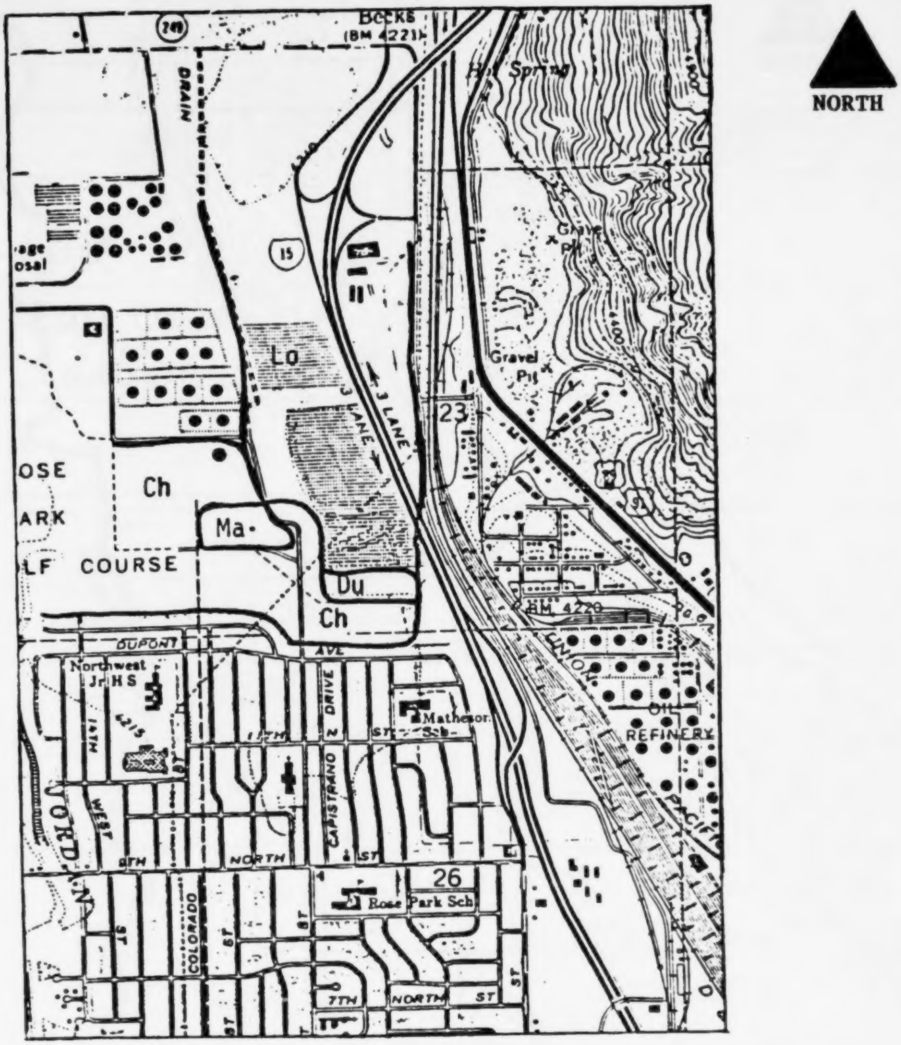
Four series are present in the area of the Rose Park Sludge Pit. The natural soils are classified as Chipman silty clay loam. Soil borings taken around the sludge pit show the upper 12 feet (3.7 m) of natural soil to be generally soft to firm, light gray to brown, interbedded silty clays, clayey silts, and loose fine sands. Soil permeability is moderately slow (10^{-4} to 10^{-5} cm/sec), runoff is very slow, and organic matter content is high.

As Figure 3 illustrates, the other three soil series described by the Soil Conservation Service are miscellaneous land types. The disposal pit is classified as a "dump." The "loamy borrow pits," located north of the site, consist of deep, stratified alluvial sediments where from 2 to 20 feet (0.6-6.1 m) of material has been removed from the surface. The material that remains is predominately sandy loam to clay loam in texture, with layers of sand or clay in some places. Soils classified as "made lands" are found along the eastern side of the site along Interstate 15. This area is covered with material such as gravel, rocks, and concrete slats, and has been built up for industrial use.

Hydrogeology

300.68(e)(2)(i)
(D) hydrogeologic
factors

The subsurface geology in the area of the Rose Park site is not readily distinguishable from the surface soils. The unconsolidated deposits of clay, silt, sand, and gravel laid down irregularly chiefly as stream, lake, or delta deposits are found to depths of hundreds of feet. The variety of these various deposits in the Jordan River Valley is complex and this has been the basis for dividing the valley into districts and subdistricts. These, in turn, serve as a basis for characterizing the geology, the water bearing properties of the depoits, and the quality of the groundwater. As shown in Figure 4, the Rose Park site is located in the northeast corner of the East Lake Plain subdistrict near the boundary of the City Creek Fan subdistrict. The deposits in the East Lake Plain subdistrict are characterized by lake plain deposits possibly overlain by alluvial fan or floodplain deposits. The sediments are primarily blue-gray or yellow lake-bottom clays, with intercalated discontinuous thin lenses of gravel. Drillers' logs generally show less than 25 percent gravel in intervals and deposits that are generally greater than 1000 feet (300 m) thick. The City Creek Fan subdistrict consists principally of a pre-Lake Bonneville alluvial fan deposited by City Creek. This subdistrict consists of well-sorted, permeable deposits that are mostly boulders and gravel. Gravel was reported in more than 50 percent of the intervals listed in drillers' logs. The deposits in this subdistrict are about 500 feet (150 m) thick. Figure 5 shows drillers' logs for two wells, one in the East Lake Plain subdistrict and the other in the City Creek Fan subdistrict, and illustrates the difference in the thickness of sand and gravel layers in the two subdistricts.



Key

Ch - Chipman silty clay loam
Ma - Made lands
Du - Dumps
Lo - Loamy borrow pits

(SCALE UNKNOWN)

Figure 3. Soil Series Associated with the Rose Park Site, Salt Lake City, Utah

Source: Fred C. Hart Associates 1979

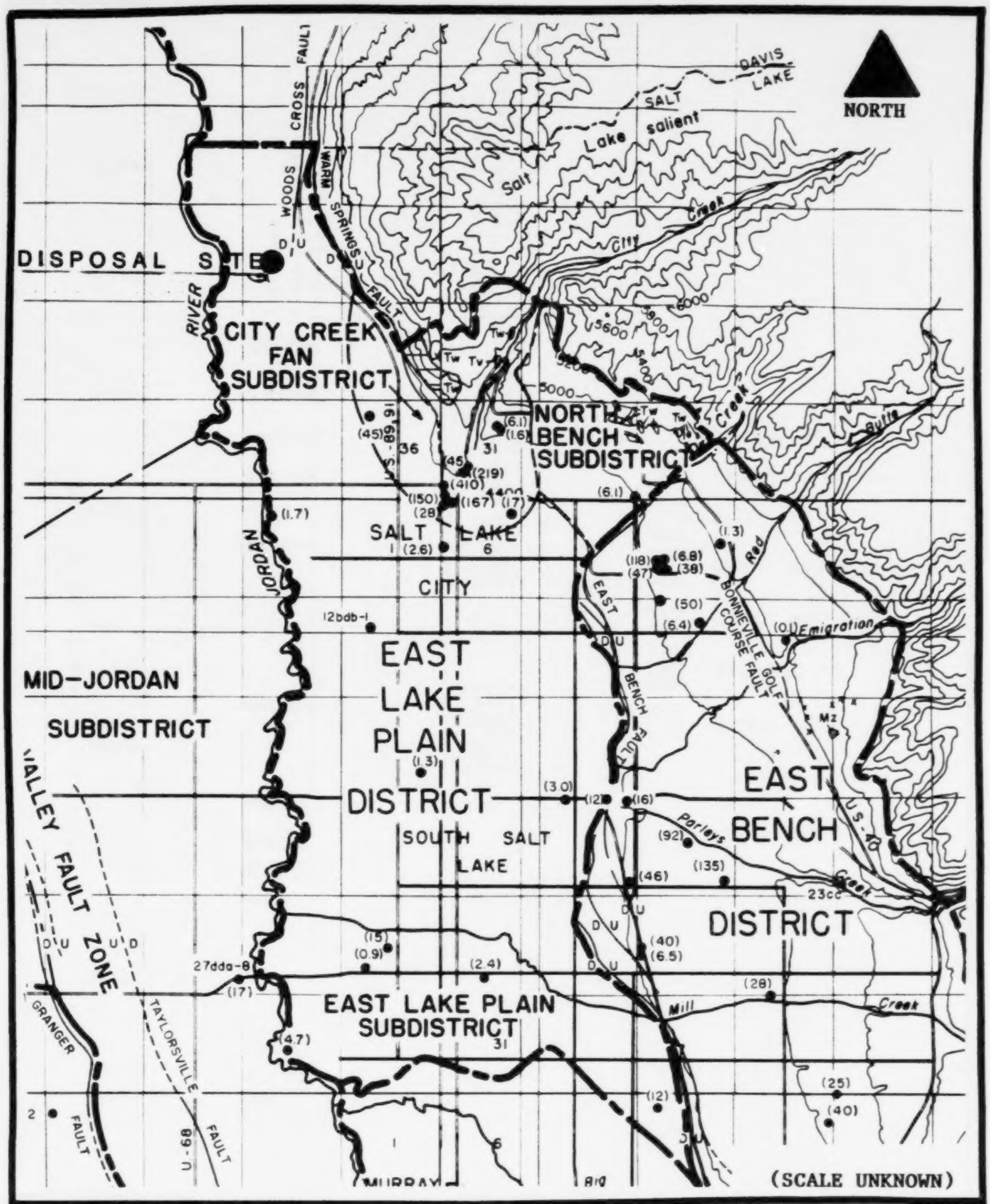


Figure 4. Geologic Map Showing Location of the Rose Park Site with Respect to Various Districts and Subdistricts in the Jordan Valley, Salt Lake City, Utah

Source: Marine & Price 1964

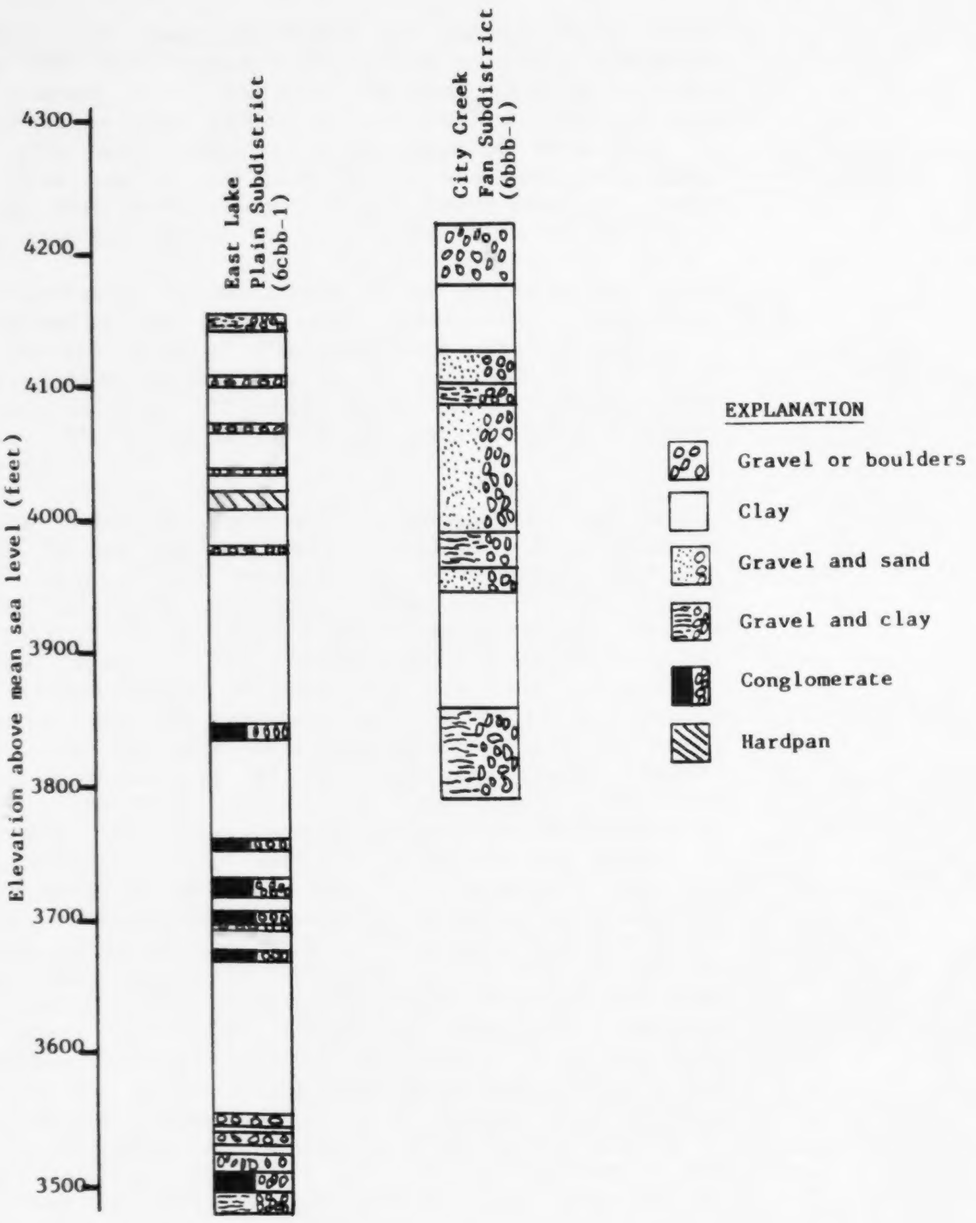


Figure 5. Graphic Logs of Two Wells in East Lake Plain and City Creek Fan Subdistricts (see Figure 4 for well locations)

Source: Based on Marine & Price 1964

Drillers' logs developed by Amoco during their August 1981 field investigation show that the sediments from a depth of 12 to about 30 feet (3.6 to 9.1 m), where borings were completed, consist of soft to firm silty clay and clayey silt interbedded with firm to dense fine sand. The sand lenses are generally thin, although some areas contain thick, dense sand and gravel layers more typical of the City Creek Fan subdistrict.

Groundwater in the Jordan River Valley occurs under both artesian and water table conditions. The water table in the area of the Rose Park site is generally encountered at depths of 5 to 10 feet (1.5 to 3.0 m) as reported in the FIT and Amoco field investigation reports. The water is saline and is unsuitable for most purposes.

The artesian aquifer is encountered at depths between 30 and 600 feet (9.1 to 183 m) and consists of gravel lenses. The artesian water, although hard, is suitable for most purposes. However, residents from Salt Lake City now obtain their water supply from a municipal system. The closest well, 2 miles (3.2 km) south of the site, is used only for lawn irrigation. The size and the productivity of wells previously operated in the area were determined by the thickness and the permeability of the sand and gravel lenses. Water in the East Lake Plain subdistrict comes from small, discontinuous lenses of gravel that are mostly at depths of 250 to 300 feet (76 to 91 m), but ranged in depth from about 30 to 600 feet (7.6 to 183m). Specific capacity of eight large-diameter (greater than 6-inch or 15.2-cm) wells in the subdistrict range from 0.9 to 15 gpm per foot (0.06 to 1.0 cubic meters per second per meter) of drawdown with an average of 4 gpm per foot (0.28 cubic meters per second per meter) of drawdown. The sand and gravel deposits of the City Creek Fan subdistrict, in the area of the Rose Park site, yield significantly larger quantities of water. The specific capacity of seven large-diameter wells ranged from 28 to 410 gpm per foot (1.9-28.5 cubic meters per second per meter) and averaged 150 gpm per foot (10 cubic meters per second per meter) of drawdown.

Generally speaking, the Jordan River Valley has a large potential for production of additional groundwater. There has been some concern that as reliance on the deeper aquifer increases, the artesian head could reverse and any contaminated groundwater in the water table aquifer could recharge the deeper aquifer. This is one reason that drains and canals in the vicinity of the Rose Park site have become an issue of concern. The subsurface geology in this area, with its irregular, interbedded sand and clay layers, is quite complex and a detailed hydrogeologic investigation would be needed to determine the potential for contamination of the deeper aquifer.

There has been some conflicting data on the direction of groundwater movement in the area of the Rose Park site. In general, the movement of groundwater in the Jordan River Valley is in a northwest to west direction. However, in the immediate vicinity of the site, groundwater flow is severely affected by a series of sewers, drains, and pipe alleys. Amoco conducted several sets of rate and flow studies in an effort to define flow conditions around the site. The results showed that except for near surface flow, disruptions caused by local artificial drainage paths, the general direction of flow around the site is also from southeast to northwest. Other investigators have shown the direction of flow to be towards the southwest, but may have been measuring the flow in artificial drainage paths.

WASTE DISPOSAL HISTORY

From the 1920's until the mid-1950's, petroleum refinery wastes from the Utah Oil Refining Company, consisting primarily of acid sludges, were deposited in the Rose Park Sludge Pit. The refinery process used during this period consisted of treatment of the crude fractions with sulfuric acid; this manner of treatment produced highly acidic and somewhat sulfonated tar. This tar was disposed of in layers at the Rose Park site; laminae were separated by layers of lime and soil. Drums of the same material were occasionally dumped into the pit along with other industrial and construction debris. After the pit was closed in 1957, an unknown amount of the waste was excavated and hauled to a nearby dump. Information on the amount of waste removed and the place to which it was taken is not entirely clear, but some sources indicate that as much as 100 truckloads were taken to a dump at 6200 W. on North Temple. The remaining waste was left in place and covered with soil in the early 1960's.

DESCRIPTION OF CONTAMINATION

Between the time of the discovery of significant problems with the Rose Park Sludge Pit in 1976 and the initiation of the remedial action in December 1982 by Amoco, a number of field investigations were undertaken by EPA's Technical Assistance Panels (TAP) and FIT contractors, Amoco, and Salt Lake City, in an effort to characterize the wastes and to define the extent of the problem.

300.68(e)(2)(i) (B) amount and form of substances present

Results of a February 1977 analysis of a sludge sample, directed by the Salt Lake City-County Health Department, indicated that the sludge was a black, acidic, tarry substance with a softening point of 100 to 120°F (38-49°C). On days when the ambient temperature exceeded 90°F (32°C), the sludge was semisolid, leading to the formation of pits on the surface of the site. Gas samples (sampling method not specified) showed that an acid mist, thought to be sulfuric acid, was emitted when the sludge was agitated. This description was consistent with later reports that indicated that the bulk of the sludge came from sulfuric acid treatment of light petroleum products. The analysis also explained the eye, nose, and lung irritations reported by construction workers in 1976. From early 1977 through May 1978, the City directed the Utah Geological Mineral Survey (UGMS) to determine whether groundwater contamination was occurring in the immediate vicinity of the sludge pit. The results, although preliminary, suggested that the sludge pits, as well as the refineries to the north, may have been contributing oil and grease to downgradient groundwater. However, UGMS was not in a position to further define the contamination problem.

In 1979, the EPA Region VIII Technical Assistance Panel's Contractor was called in to further evaluate the extent of the problem and to make recommendations for immediate and long-term solutions. This was the beginning of EPA's involvement in four major site investigations (through both TAP and FIT contracts) before Amoco initiated remedial action in December 1982. The nature of these investigations is summarized in Table 1. The first two investigations were conducted under the TAP and FIT programs, respectively. The third study was also conducted under FIT, but samples were also analyzed by Amoco. The last study was undertaken by Amoco with samples collected and analyzed by the FIT as well.

TABLE 1. SUMMARY OF SITE INVESTIGATION ACTIVITIES

DATE OF FIELD INVESTIGATION	INVESTI- GATORS	OBJECTIVES OF THE INVESTIGATION	TYPES OF SAMPLES ANALYZED	ANALYSES PERFORMED	DESCRIPTION OF THE REMEDIAL INVESTIGATION
July 1979	TAP	Initial study to characterize the wastes and and extent of contamination under EPA Technical Assistance Panel's Programs	Groundwater Soil Sludge	pH, sulfate, TOC, and two indicator components, dichlorobenzene and xylene, which were detected in a sludge sample taken to weeks earlier	• 16 boreholes were drilled by auger throughout the park, the adjacent Golf course, and the Amoco borrow pits area • Additionally, 6 sludge samples and two sewer samples were taken.
August to November 1980	FIT	Further site characterization under EPA's Field Investigation of Uncontrolled Hazardus Waste Site Progam (FIT)	Groundwater Soil Sludge	• pH, temperature, sulfide, priority pollutants • Ground penetrating fader, resistivity, and electromagnetic surveys	• 14 boreholes were drilled by auger for taking water and soil samples • 3 trenches were excavated by backhoe also for taking water, soil, and sludge samples • Subcontractors performed geophysical surveys using electrical resistivity, ground penetrating, radar, anbd electromagnetics to locate drains and canals and the boundaries of the sludge pit
May-June 1981	FIT and Amoco	• Resolve discrepancies in data from previous two investigations	Soil Sludge Soil leachate	• pH, sulfate, TOC, priority pollutants • Soils test for permeability, moisture densities, and liquid, plastic and shrinkage limits	• Soil and sludge samples taken from 3 boreholes and 2 storm drains. • Installation of groundwater monitoring wells was attempted but was found to be inadequate due to have silting

(continued)

TABLE 1. (CONTINUED)

DATE OF FIELD INVESTIGATION	INVESTI-GATORS	OBJECTIVES OF THE INVESTIGATION	TYPES OF SAMPLES ANALYZED	ANALYSES PERFORMED	DESCRIPTION OF THE REMEDIAL INVESTIGATION
August to November 1981	Amoco and FIT	• Amoco felt that field investigation data to date was not adequate to define the problem and requested that they conduct their own investigation • Installation of new groundwater monitoring wells • EPA requested FIT to determine if elevated concentrations of organic vapors occured around the sludge pit or residential areas	Sludge, soil groundwater groundwater Flow direction soil, leachate air	Varied with sampling date - see text	• 6 exploratory boreholes were drilled using 6-inch (15.2-cm) hollow stem flight augers and 6 groundwater monitoring wells were installed • Amoco took soil, sludge, and groundwater samples in August 1981; groundwater flow measurements were also made • Amoco and FIT took groundwater samples and made flow measurements in October 1981 • Also in August 1981, an OVA was used to measure organic vapors; 14 monitoring wells, 3 storm drains, a sludge sample, 6 private residences, and an elementary school were sampled

The first remedial investigation was initiated in July 1979. In advance of this major field effort, the TAP contractor collected and analyzed a sludge sample and found high concentrations of xylene and o-dichlorobenzene among other organics (including toluene and other benzene derivatives; and derivatives of anthracene, napthalene and phenanthrene). Groundwater and soil samples were collected from 16 auger-drilled boreholes that were drilled to depths of 10 to 20 feet (3.0-6.1 m) in a cruciform pattern outside of the fenced sludge pit area. Additionally, five sludge samples and two sewer samples were taken. Subsequent analysis for xylene and o-dichlorobenzene (indicator compounds), Total Organic Carbon (TOC), pH, and sulfate showed that there was no appreciable migration of contaminants, but that TOC, xylene, and dichlorobenzene were sufficiently high at points south and east of the assumed sludge pit boundary to suggest that the boundary extended beyond the fenced area. Although the indicator compounds were found at low concentrations in only one groundwater sample and were not found at all in subsequent investigations, their reported presence sparked further concern over the site and prompted EPA to recommend interim remedial measures and to conduct further interim remedial investigations.

300.68(f)
remedial
investigation

300.68(e)(2)(i)
(B)amount and
form of substances
present

A more comprehensive field investigation was initiated in August 1980 by EPA's FIT. Soil, sludge, and groundwater samples were again collected from 4-inch (10-cm) auger-drilled boreholes that extended to depths of up to 19 feet (5.8 m) at points shown on Figure 6. In addition, three trenches were excavated by backhoe and were sampled. Samples were analyzed for acid and base neutral organics, metals, pH, and sulfide. Organic and inorganic analytical results of groundwater samples are shown in Table 2. Neither xylene nor dichlorobenzene were found. Anthracene, naphthalene, and phenthrene were found in the 1-3 ppm (mg/l) range, napthalene and fluoranthene in the 1-3 ppb range, and several other organics were detected at trace levels. Inorganic analysis showed elevated concentrations of lead, arsenic, copper, zinc, chromium, and barium (ppm; mg/l levels). During the week of October 21, 1980, a subcontractor to the FIT conducted an electrical resistivity survey (using a GER-103 steady state DC resistivity unit). From the interpretation of this data, the boundary of the disposal area was found to extend approximately 20 to 30 feet (6.1-9.1 m) further

300.68(e)(ii)
extent of sub-
stance migration

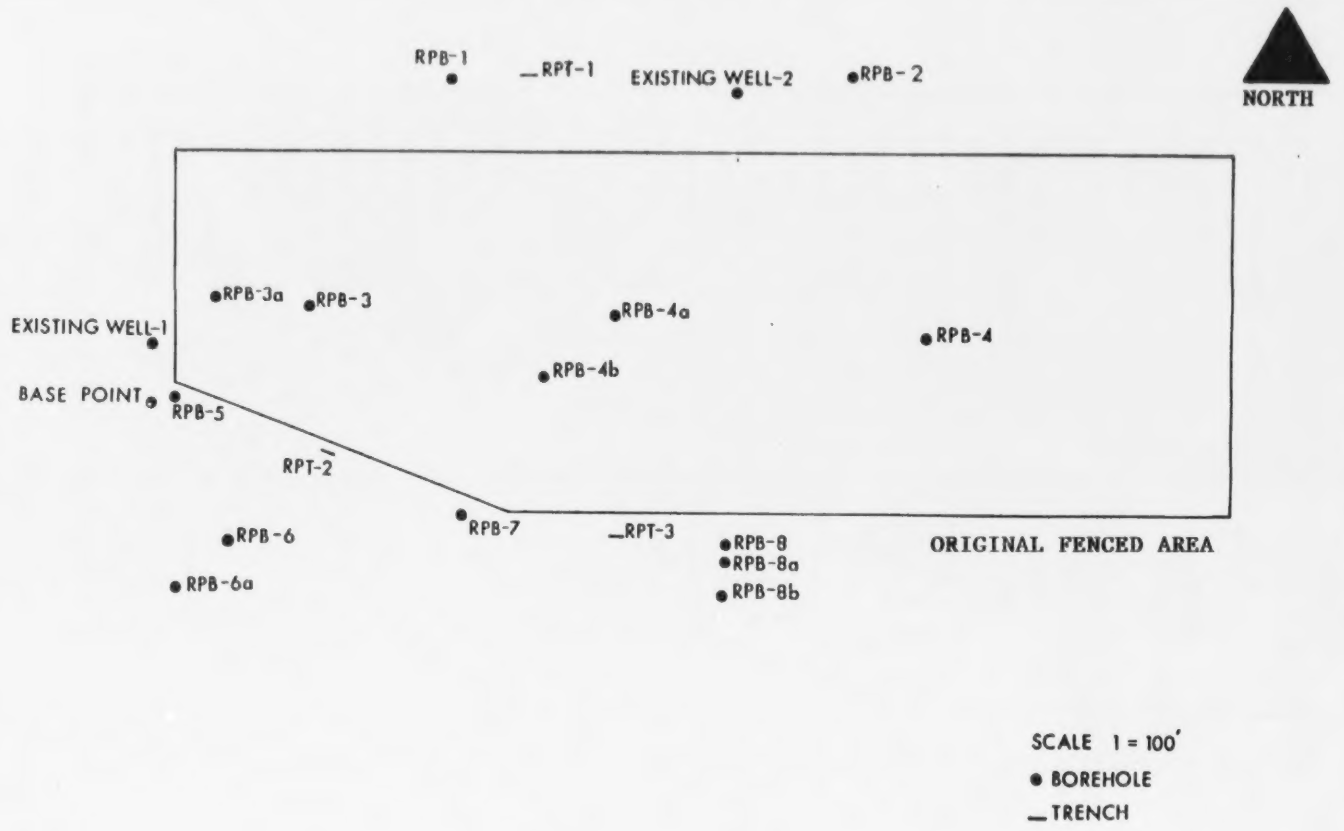


Figure 6. Location of FIT Test Boreholes and Trenches, August 1980 Field Investigation, Rose Park Site, Salt Lake City, Utah

Source: Fred C. Hart Associates 1980b

TABLE 2. SUMMARY OF FIT ANALYSIS OF GROUNDWATER SAMPLES COLLECTED IN AUGUST 1980 AND NOVEMBER 1981 (PPM;MC/L)

ORGANICS	AUGUST 1980	NOVEMBER 1981
Pentachlorophenol	0.010-0.024	ND
Bis (2-ethylhexyl) phthalate	0.010	0.0108 (#1)*
Napthalene	0.014-0.143	ND
Anthracene	0.010-2.9	ND
Phenanthene	0.010-3.5	ND
Pyrene	0.015-2.7	ND
Toluene	0.001-0.008	ND
Beta - HGC	0.001-0.008	ND
Fluoranthene	0.284	ND
Di-n-butylphthalate	0.010	ND
Phenol	0.010	0.010 (#4)
2, 6 dinitrotoluene	0.010	ND
Benzene	0.010	ND
Xylene	ND	ND
Dichlorobenzene	ND	ND
Cyanide	0.01	ND
Arsenic	0.01-1.2	0.12-0.90
Beryllium	0.002-0.008	0.002-0.006
Cadmium	0.08-0.092	0.01-0.76
Chromium	0.08-0.982	0.01-0.76
Cobalt	0.03-0.32	0.01-0.31
Copper	0.02-1.03	0.04-1.08
Lead	0.04-1.88	0.04-0.22
Mercury	0.01-0.906	0.001
Nickel	0.12-0.61	0.08-0.8
Sulfide	0.05	0.05
Selenium	0.01	0.05-0.59
Silver	0.02	0.02
Vanadium	0.22-1.2	0.03-1.06
Zinc	0.48-26.0	0.2-2.59
Sodium	498-2990	351-3410
Aluminum	13-578	9.25-451
Barium	0.72-4.9	0.14-0.7
Calcium	1056-4160	759-3570
Tin	0.1	ND
Iron	63.8-1040	13.9-739
Magnesium	91.8-818	84.9-257
Manganese	43-11.7	1.73-16.5
Boron	0.27-5.66	1.63-2.29

*Organic contaminants in the November 1981 analysis were detected in one well sample only. The number of the well is indicated in parenthesis.

Source: Fred C. Hart Associates 1982

south in the vicinity of the restroom. The survey also confirmed the locations of two buried canals that had been previously identified by the County Health Department. One canal runs south from the southeast corner of the site and the other runs east from the east side of the site. In an effort to further define the canals and the ditches, another subcontractor performed a geophysical survey using ground penetrating radar (GPR) and electromagnetics (EM). The GPR was limited to a maximum depth of 6.1 feet (2 m) as a result of naturally high conductivities in the area and EM was unreliable at some points due to noise and highly variable subsurface conditions. Despite these limitations, the combined data was successfully used to map the drainage canals and ditches. The canals and ditches' approximate location is shown in Figure 7. The survey also showed that conductivity of the sludge pit was lower than areas immediately to the north and east, suggesting that the sludge pit was not the major source of conductive material.

300.68(e)(2)(ii)
extent of
migration

The results of the geophysical investigations, the knowledge that a number of private residences were built over or adjacent to the canals, and EPA's interest in remedying the entire contamination problem (canals as well as the sludge pit), led EPA to conduct sampling of the canals in the residential area. Analytical results showed elevated concentrations of a number of metals and organics such as pyrene, fluoranthene, phenanthene, bis-2 ethylphthalate, etc. However, at about the time these data became available to EPA for interpretation, Amoco offered their technical and financial assistance to the City in assessing the contamination problem at the sludge pit and in implementing remedial actions. Since a number of companies were known to have discharged into the canals, the decision was made to concentrate exclusively on remedial actions for the sludge pit at this time.

Amoco's involvement in the remedial investigation activities began in May 1981 when they analyzed split samples of soil and sludge collected by the FIT from auger-drilled boreholes made during the week of May 24, 1981 (sampling points shown in Figure 8). The purpose of this survey was to resolve discrepancies between the July 1979 and August 1980 field investigations. Amoco stated, as a result of their chemical analysis, that

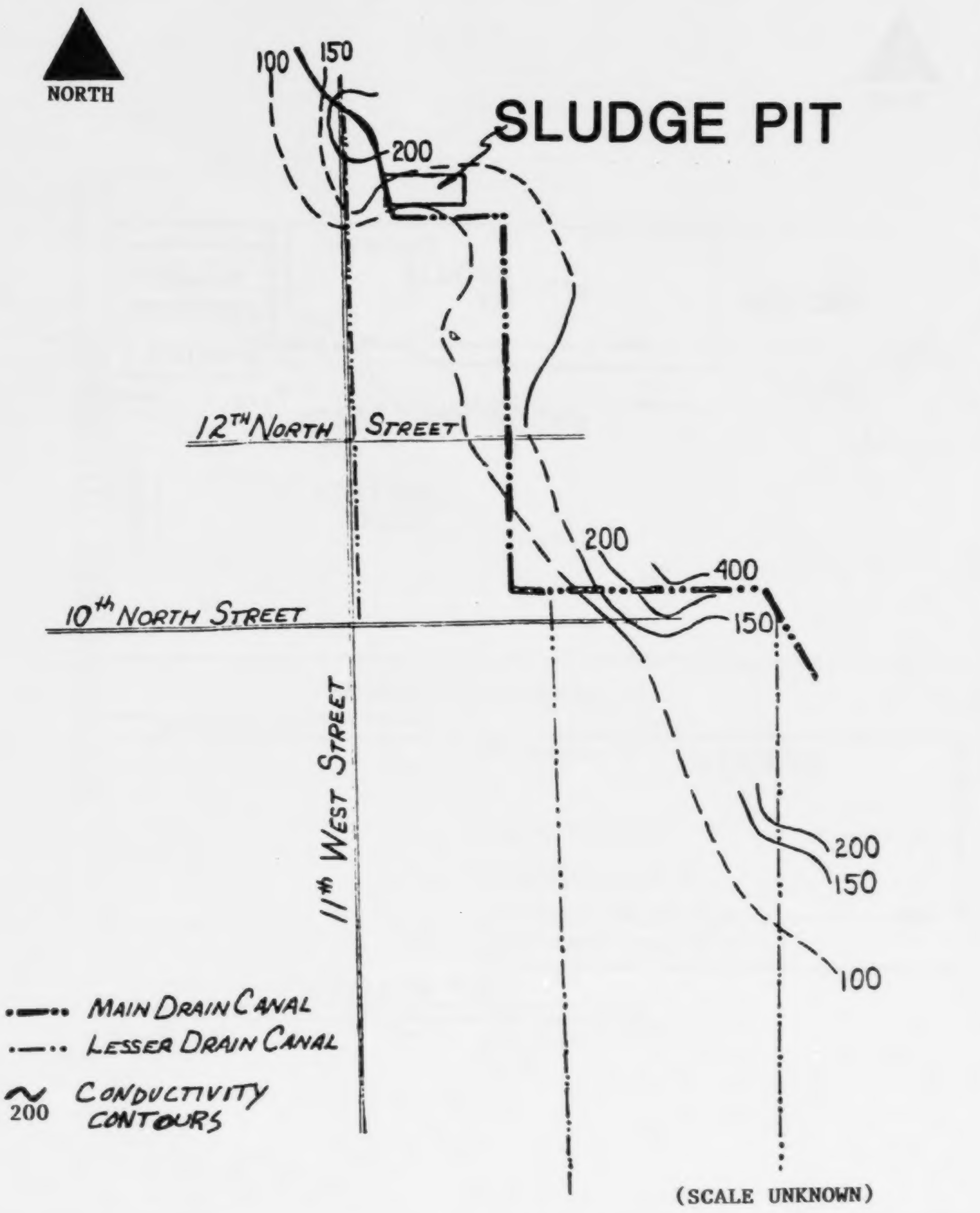


Figure 7. Approximate Location of Drainage Canals, Rose Park Site, Salt Lake City, Utah

Source: Technos 1980

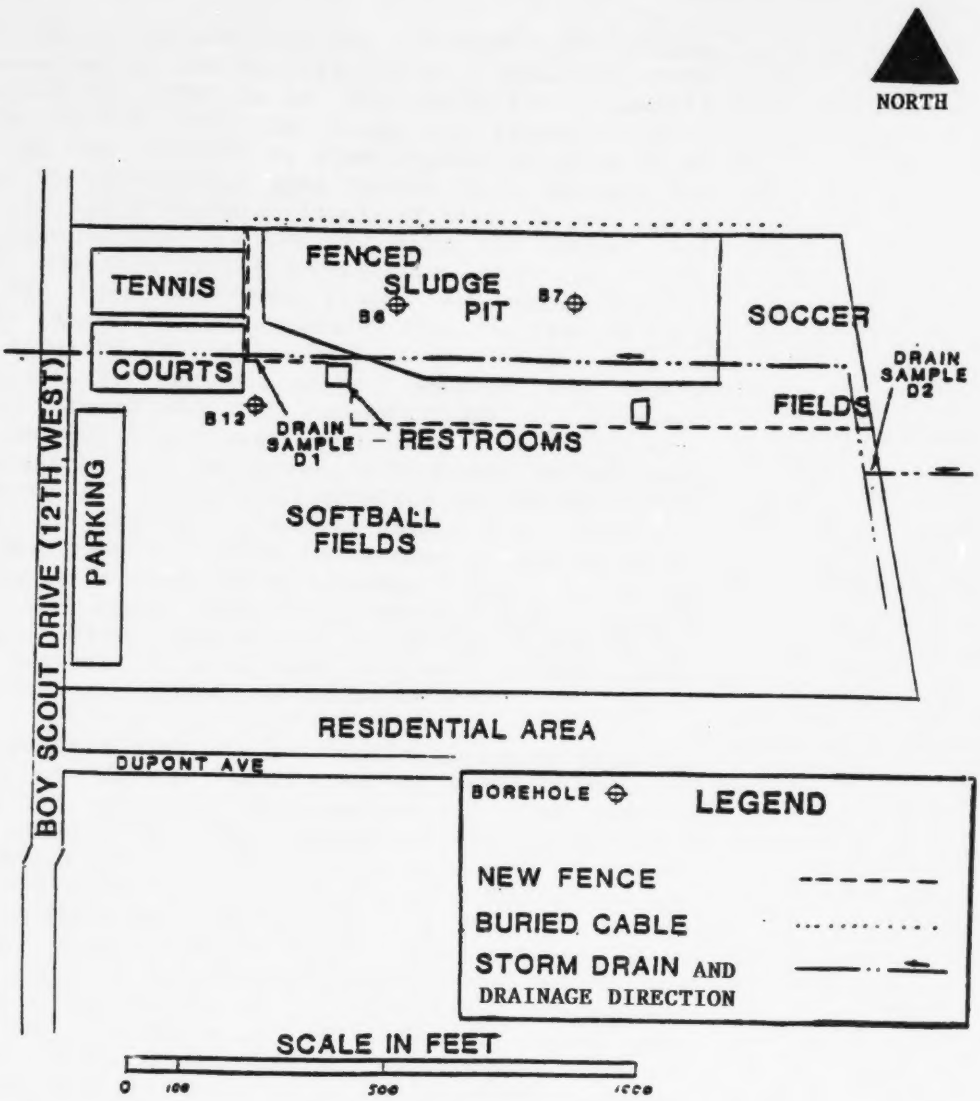


Figure 8. Location of FIT Sampling Points, May 1981 Field Investigation, Rose Park Site, Salt Lake City, Utah

Source: Fred C. Hart Associates 1982

neither the sludge pit soil nor the sludge pit surface tar showed any of the characteristics of hazardous waste as defined by RCRA in 40 CFR, Part 261. Amoco's analysis of soil from the sludge pit showed slightly acidic pH, the presence of some organic material (0.01 percent for background soil versus 2.40 percent for sludge pit soil), elevated levels of lead (24 ppm; mg/kg for background soil and 224 ppm; mg/kg for sludge), and slightly elevated levels of selenium (0.8 and 3 ppm; mg/kg for background and sludge pit soil, respectively). Amoco further concluded that the lead is in a stable form and is not leachable into the groundwater. In contrast, GIT analysis of soil samples taken during May 1981 showed elevated concentrations of chromium, copper, selenium, and zinc, as well as lead. They also found organics such as pyrene, anthracene, phenanthene, benzopyrene and benzo (ghi) perylene in concentrations of 10-25 ppm (mg/kg) in a soil sample from within the sludge pit. Table 3 shows the maximum concentration of contaminants detected in soil/sludge samples during the May 1981 and August 1980 field investigations. Amoco's analysis of water samples from the drains (Figure 8) and from a borehole located just southeast of the tennis court showed no evidence of contamination.

Amoco felt that the information produced from the May 1981 program was insufficient to properly evaluate existing or potential problems at the site and to develop remedial actions. Therefore, they volunteered to conduct a more detailed investigation at their own expense. Six exploratory boreholes were drilled and six monitoring wells were installed during 1981, as shown in Figure 9. Soil and sludge samples were tested by Amoco for pH, organics, priority pollutants, total metals, and RCRA Extraction Procedure (EP) Toxicity. Groundwater samples were tested for pH, total organic carbon, conductivity, phenols, and priority pollutants. Priority pollutants were not detected in any groundwater samples using GC/MS. GC/MS scans at high sensitivity were also conducted on the list of priority pollutants. Although a number of trace organics were identified (Table 4), they were present below the quantification limit of 10 ppb (ig/1). Also, it was suspected that some of these organics were components of the solvent cement used during the installation of the PVC pipe in the monitoring wells. Although elevated levels of the metals selenium, chromium and lead were found in soil

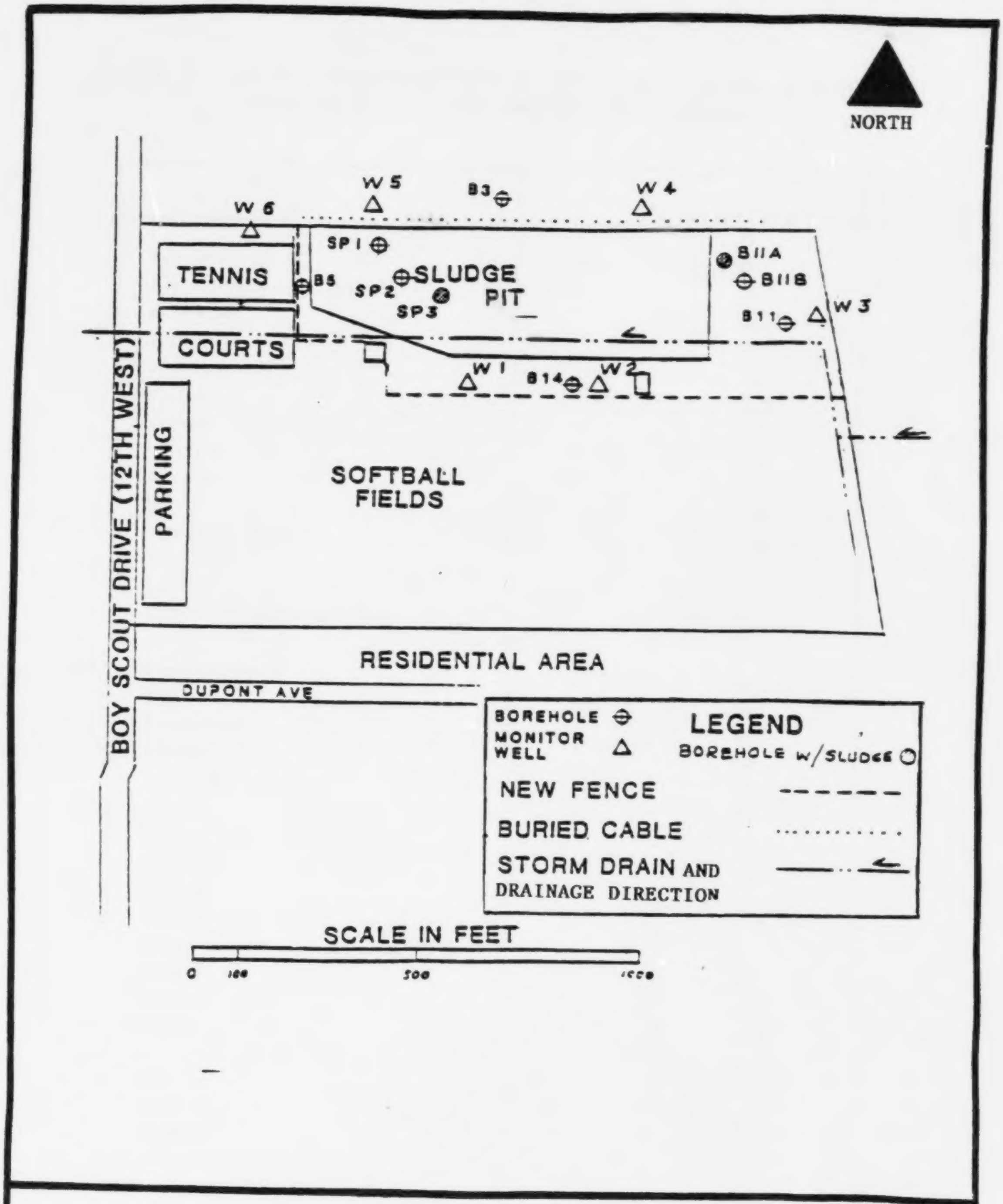


Figure 9. Location of Amoco Test Borings and Monitoring Wells, August 1981, Field Investigation, Rose Park Site, Salt Lake City, Utah

Source: Amoco 1981c

TABLE 3. MAXIMUM CONCENTRATIONS OF ORGANICS DETECTED IN SLUDGE BASED ON AUGUST 1980 AND MAY1981 SAMPLING

Compound	Sludge ppm (ug/g Soil)
Pentachlorophenol	ND
Bis (2-ethylhexyl) phthalate	ND
Napthalene	ND
Anthracene	10.0
Phenanthene	10.0
Pyrene	25.0
Toluene	2.1
Dieldrin	3.40
PCB-1260	7.65
Endrin	2.08
Heptachlor epoxide	0.04
Toxaphene	1.89
PCB 1254	0.18
Di-n-butylphthalate	10.0
Phenol	5.0
Benzoanthracene	22.0
Chrysene	10.0
Benzopyrene	60.0
Acrolein	1.3
Benzo (ghi) perylene	2.5
Benzene	1.0
Arsenic	118.0
Beryllium	10.0
Cadmium	7.6
Chromium	30.0
Cobalt	ND
Copper	78.0
Lead	654.0
Nickel	60.0
Sulfide	ND
Selenium	50.0
Silver	5.0
Vanadium	ND
Zinc	191.0

Source: Fred C. Hart Associates 1982

TABLE 4. PROBABLE OTHER ORGANICS IN GROUNDWATERA (1) BASED ON AMOCO'S GC/MS SCAN OF AUGUST 1981 SAMPLES

Well No. 1	Tetrahydrofuran (2)
	Hexadecanoic Acid
	N-(4-Ethoxphenyl)-Acetamide
Well No. 2	2-Propanone
	Butane
	Methl Oxirane
Well No. 3	Tetrahydrofuran (2)
	Ethyl Oxirane
	4-Ethyl - 1,3 - Dioxolane
Well No. 4	2-Propanone
	Butane
	Methyl Oxirane
	Cyclohexane
	Methyl Cyclopentane
	Dimethyl Cyclohexane
	Trimethyl Cyclohexane
	Tetrahydrofuran (2)
Well No. 5	None
Well No. 6	None

(1) Identified, but not quantifiable, at or below 10 ppb.

(2) Tetrahydrofuran is a component of PVC pipe cement

Source: Fred C. Hart Associates 1982

TABLE 5. RESULTS OF AMOCO'S ANALYSIS OF SOIL SAMPLES - AUGUST 1981.

PARAMETER	BOREHOLE				
	B-3	B-5	B-11	B-11A	B-14
pH	8.3	8.6	8.3	8.0	8.4
Organics, wt.%	0.1	0.1	0.14	1.6	0.1
Total Metals, ppm:					
Arsenic	11	12	12	11	17
Barium	50	84	80	58	46
Cadmium	1	1.2	1.2	1	1
Chromium	32	38	36	36	38
Lead	36	17	60	122	16
Mercury	0.06	0.02	0.12	0.22	0.004
Selenium	164	210	176	70	212
Silver	10	10	10	10	10

METALS LEACHABLE BY RCRA EXTRACTION PROCEDURE, mg/l	RCRA EP TOXIC LIMIT, mg/l	BOREHOLE				
		B-3	B-5	B-11	B-11A	B-14
Arsenic	5.0	0.3	0.3	0.3	0.3	0.3
Barium	100.0	0.38	0.41	0.53	0.36	0.41
Cadmium	1.0	0.06	0.06	0.06	0.06	0.06
Chromium	5.0	0.41	0.36	0.40	0.56	0.39
Lead	5.0	0.07	0.07	0.07	0.07	0.07
Mercury	0.2	0.002	0.001	0.0002	0.0002	0.0002
Selenium	1.0	0.8	0.8	0.8	0.8	0.8
Silver	5.0	0.5	0.5	0.5	0.5	0.5

Source: Fred C. Hart Associates 1982.

TABLE 6. AMOCO ANALYSIS ROSE PARK WATER SAMPLES - OCTOBER 1981.

PARAMETER	RCRA EP TOXIC LIMIT	WELLS					
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
pH	-	7.2	7.1	7.0	7.1	6.9	7.0
Conductivity, umhos/cm	-	4417	3653	5950	21000	17125	3900
TOC, mg/l	-	128	31	14	10	23	19
Total Metals, mg/l:							
Arsenic	5.0						
Barium	100.0	0.02	0.05	0.07	0.10	0.09	0.04
Cadmium	1.0	0.06	0.06	0.06	0.06	0.07	0.06
Chromium	5.0	0.36	0.31	0.29	0.40	0.47	0.14
Lead	5.0	0.07	0.07	0.07	0.07	0.07	0.07
Mercury	0.02	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
Selenium	1.0						
Silver	5.0	0.05	0.05	0.05	0.05	0.05	0.05
Calcium	No Limit	560	530	650	870	830	166
Magnesium	No Limit	174	129	104	153	201	79
Manganese	No Limit	0.90	0.54	2.8	1.3	3.7	0.44
Sodium	No Limit	590	330	620	3860	2860	910

1. Chloride (salt) concentrations in Wells Nos. 4 and 5 in the range 2,000-5,000 mg/l. In the other wells, chloride ranged from 55 to 65 mg/l.
2. Nitrate concentration in Wells Nos. 1 and 2 ranged from 55 to 65 mg/l. In other wells, nitrate was 2 mg/l or less.
3. Means not detected at the indicated limit.
4. Other metals not detected at indicated detection limits were: Sb (0.3), Be (0.002), Cu (0.02), Ni 90.2), Te (1.2), V (0.03), and Zn (0.5).

Source: Fred C. Hart Associates 1982

samples (Table 5), RCRA extraction procedure limits were not exceeded in the leaching tests conducted on solid samples or in the water samples. The groundwater monitoring wells were again sampled by Amoco in October and by the FIT in November 1981. Results are shown in Tables 6 and 2 for Amoco and the FIT, respectively. Again, Amoco detected no organic priority pollutants. The concentration of metals was consistently below the RCRA EP Toxic limits.

The results of the FIT analysis also showed that only a few organic priority pollutants were present and that metal concentrations, although elevated, were consistently well below the RCRA EP Toxic limits.

Concurrent with Amoco's monitoring well installation in August 1981, EPA requested that the FIT conduct an Organic Vapor Analysis (OVA) survey around the sludge pit and in the residential area adjacent to the petroleum canals. Fourteen monitoring wells, three storm drains, samples of sludge material, six private residences, and an elementary school were examined for volatile emissions. Only one storm drain showed significant elevation of volatiles (gasoline volatiles) and this was likely to be the result of a May 1981 Amoco product spill.

Trace amounts of benzene (ppb; ug/l range) were detected in six of the monitoring wells and in a sludge sample. As the distance from the pit increased, the vapor readings in the wells decreased to background levels or had readings due to methane. The survey of crawl spaces in homes and in the elementary school located over the former canals showed vapor level readings equivalent to background levels.

One other aspect of the August to October site investigation that deserved mention is Amoco's detailed analysis of a sludge sample. The results of this analysis are shown in Table 7.

The organic portion of the sludge is a high boiling, highly aromatic oil containing considerable tarry materials and is high in sulfur and oxygen. This suggests a sulfonated sludge as would be produced from sulfuric acid treatment to remove olefins and aromatics from refinery products.

TABLE 7. RESULTS OF AMOCO'S ANALYSIS OF SLUDGE

pH - 5.3

Analysis of oil, solids, water, and ash content:

- 33.4% Oil
- 44.5% Solid
- 40.4% Ash
- 22.1% Water (by difference)

A simulated distillation of the oil fraction:

- 5% Gasoline
- 5% Kerosene
- 60% Gas oil-heating oil
- 30% Residue

Liquid chromatographic breakdown of the oil fraction:

Saturated 34%		Aromatics 62%	
Paraffins	13.6%	Monocyclic	14.6%
Naphthenes	15.3%	Dicyclic	25.1%
		Tricyclic	13.0%
		Tetracyclic	6.6%
		Pentacyclic	1.3%

Analysis of the ash portion for metals and anions:

AL	3.4%	Mg	1.2%
Ca	5.0%	Na	5.0%
Fe	2.0%	SO_4	7.7%

Other major components of the ash included typical earth alkali metals present as silicates, carbonates, and sulfates.

Source: Amoco 1981b.

Summary of Analytical Results

There are some discrepancies in analytical data from the various investigations conducted by the FIT, as well as discrepancies between Amoco and the FIT data. Notably, the FIT detected a number of organic priority pollutants in groundwater samples collected during the 1979 and 1980 surveys which were not detected during the November 1981 sampling of Amoco groundwater monitoring wells. These differences may be due to the fact that early samples were collected from boreholes, whereas the October 1981 samples were collected from properly installed monitoring wells, or the differences could be attributable to the presence of localized pockets of wastes. The major difference between FIT data and Amoco data is that Amoco detected no organic priority pollutants in any groundwater samples on any occasion. Despite these differences in analytical results, an overview of all sampling data leads to the basic conclusion that soil, groundwater, and air were not significantly influenced by the sludge. This can be attributed to the low permeability soils and to the viscous, low solubility nature of the waste material itself. Hazard assessments performed by the FIT and Amoco using data from the Registry of Toxic Effects of Chemical Substances and RCRA EP Toxicity limits, respectively, indicated that in the absence of direct contact, the potential for adverse health effects due to the sludge was low.

PLANNING THE SITE RESPONSE

Initiation of Site Response

The Rose Park Sludge Pit was ranked for the National Priorites List in August 1982, after the completion of all EPA and Amoco field studies described in the previous section. The composite scores from this ranking were well below those normally required for inclusion on the NPL. Yet, due to the threat of direct contact, the State of Utah requested that EPA consider Rose Park as the State's top priority site. Hence, Rose Park was listed in Group II of the NPL published on December 30, 1982.

An Intergovernmental/Corporate Cooperation Agreement was entered into by Salt Lake City Corporation, Salt Lake City/County Health Department, the Utah State Department of Health, Amoco Oil Company (Amoco), and EPA on October 29, 1982. The agreement was made so that environmental, health, and safety problems at the site could be resolved through the cooperative efforts of the interested parties. The agreement did not constitute an admission of liability or responsibility for the dumping at the site by any party.

The agreement stated that Amoco would pay for remedial actions detailed in the Selection of Response Technology section that follows. The agreement also provided for funding of a program for monitoring groundwater from wells around the site. During the first year of this program, the EPA was to provide sampling and analysis through the FIT contractor. The City would then be responsible for implementation of the monitoring program from years 2-30 and would obtain contractor services to ensure that the groundwater would be monitored.

Selection of Response Technologies

As a result of the findings of the July 1979 and August 1980 field investigations, the FIT recommended the need for both interim and long-term remedial actions at the Rose Park Sludge Pit. These recommendations were initially laid out in the December 1980 Draft Report, "Rose Park Sludge Pit Remedial Measures." The interim measures addressed in this report included recommendations for more adequate fencing and posting of new signs. Following these suggestions, the City of Salt Lake installed a 6-foot (1.8 m) high chain-link fence with a barbed wire top rail. In order to enclose the sludge found in these areas, the new fence extended the boundary of the site approximately 50 feet (15 m) to the south and east.

300.68(e)(1)
initial remedial
measures

The FIT also proposed installation of monitoring wells and installation of a cover as interim measures. The monitoring wells were installed by Amoco in August 1981. Covering of the sludge pit was not undertaken as an interim measure since it was later determined that a clay cap (together with the slurry wall) would be effective as a long-term remedial action. The FIT's December

300.68(g)
development of
alternatives

1980 report also made a preliminary evaluation of alternatives considered to be appropriate as long-term remedial actions. These various alternatives will not be discussed in this report since the FIT prepared a second report in January 1982 that modified the alternatives based on the availability of additional data on the site. However, the recommended alternative in the December 1980 report was to remove the sludge and dispose of it in an approved landfill. This alternative was recommended because the FIT and the EPA initally viewed the sludge pit as part of an overall problem that included the existence of sludge in the canal system. Because of the irregular and widespread distribution of waste sludges from various operations in the canal, FIT considered removal to be a practical alternative. This alternative was also initially considered attractive by FIT because it would eliminate the need for monitoring and allow for future use of this part of the park.

300.70(c)(2)(i)
removal of
contaminated
soil

Following submission of the December 1980 draft report, there were a number of changes that led to abandoning this alternative in favor of a containment system. In March 1981, Amoco indicated a willingness to assist in defining the nature and the extent of contamination at the sludge pit and to undertake remedial actions needed to control the waste problem at Rose Park.

300.68(f)
remedial
investigation

In December 1981, Amoco submitted the Environmental Evaluation of the Rose Park Disposal Area describing their proposed remedial action. This evaluation included the following:

- Install four additional groundwater monitoring wells (three downgradient and one upgradient).
- Install a slurry wall around the perimeter of the site (2363 feet; 720 m) that keys into the underlying silt/clay.
- Move any sludge found in and immediately outside the trench into the enclosed area. Efforts would not be made to locate and transfer sludge pockets beyond the pit area.
- Install a sand gas collection lens and a geotextile fabric membrane to preclude upward migration of sludge.

300.70(b)
remedial
actions

- Cover the membrane with a 2-foot (6-m) clay cap graded to a 2 percent slope.

- Erect a vehicular traffic barrier and post signs prohibiting traffic and digging.

- Revegetate the site.

300.68(j) extent of remedy

The FIT evaluated Amoco's proposed remedial action, as well as a number of other remedial alternatives, in their January 1982 report, "Rose Park Sludge Pit Remedial Measures." The report was not a full feasibility study and alternatives were not evaluated in detail. Table 8 summarizes the remedial technologies considered, the approximate time for implementation, and the relative cost of each technology. Detailed cost estimates were not developed. The report rejected excavation and removal and all alternatives except capping and the barrier wall on the basis that they were not cost-effective and that it was undesirable to expose the sludge by excavation. The report concluded that a soil-bentonite slurry wall, a membrane cover and clay cap, and groundwater monitoring as proposed by Amoco would provide an acceptable long-term solution for the site problems.

However, after reviewing Amoco's proposed remedial action, the FIT recommended that the southern slurry trench be relocated to include the existing drain canal. This would eliminate the need for excavation into a known sludge deposit and would ensure that the slurry would be securely installed in naturally compacted soils. They also recommended that a gas vent be included as part of the cap and that consideration be given to dredging of a potentially contaminated storm drain adjacent to the sludge pit. Of these three recommendations, only the gas vent was judged by EPA and Amoco to be appropriate for inclusion in the remedial action.

The remedial response actions proposed by Amoco and approved by EPA were formally set forth in the Intergovernmental/Corporate Cooperation Agreement, which was signed by City, State, and EPA officials and Amoco in October 1982. Subsequent to this agreement, Amoco carried out the agreed upon remedies.

TABLE 8. REMEDIAL ALTERNATIVES FOR THE ROSE PARK SLUDGE PIT SITE

		Time for	
Remedial Alternative	Description	Implementation (mos.)	Relative Cost
No Action	No further action beyond the interim remedial actions (manproofing fencing and groundwater monitoring wells)	-	-
Surface Sealing and Revegetation	Membrane cover and vegetative clay cop	1-3	Low
Barrier Wall	356° soil-bentonite slurry wall keyed into the underlying, low permeability clay stratum	1-2	Low
Encapsulation	Removal of sludge and contaminated soil, preparation of a 2-foot (.6m) thick clay-lined impoundment, reburial of the sludge, capping, and revegetation	4-8	Medium
Chemical Fixation	Excavation of the sludge and disposal at a site proximate to the sludge pit; fixed sludge will be returned to the pit or an alternate use of the sludge will be found	3-6	Medium
Land Disposal	Excavation of the sludge and disposal at hazardous waste landfill in Wescon, Idaho (350 miles away)	8-16	High
Incineration	Excavation of sludge and incineration at nearest approved facility (Deer Park, Texas, 1500 miles away)	12-16	High
Landfarming	Excavation of sludge; land application at RCRA approved landfarm	6-12	High

Source: Fred C Hart Associates 1982.

Extent of Site Response

Containment of the waste material was the primary objective of the remedial actions at the Rose Park site. The foremost reason for containment was to remove the threat of direct physical contact with the sludge and its health-threatening components. The sludge reportedly had low potential for migration and did not pose an off-site hazard to health or to the environment. However, the remedial action further minimized the potential for the flow of groundwater through the site and migration of the sludge off-site, in addition to removing the threat of direct physical contact.

The extent and the purpose of the remedial action was set forth in an Intergovernmental/Corporate Cooperation Agreement (ICCA), signed October 29, 1982 by City, State, and Federal agencies and the Amoco Oil Company. The ICCA required that the response actions be completed, to the extent possible, according to the schedule shown in Table 9. Inclement weather conditions and the need to relocate a portion of the slurry wall as a result of the wall caving into the trench forced delays in this schedule. These delays will be described further under the section entitled Design and Execution of Site Response.

The requirements for monitoring of the site to ensure the integrity of the containment system were also outlined in the ICCA. Monitoring was to be accomplished with wells constructed by Amoco. All 10 wells were to be sampled quarterly by the EPA in the first year of operation. Sampling after the first year and through year 30 of the operation of the containment system then became the responsibility of the City, although Amoco and the City jointly supplied monies for a restricted interest bearing fund from which the monitoring program would be financed. Only six of the ten wells were required to be sampled after the first year.

DESIGN AND EXECUTION OF THE SITE RESPONSE

This section describes the design and the implementation of the remedial response actions outlined in the Intergovernmental/Corporate Cooperation Agreement.

TABLE 9. REMEDIAL ACTION IMPLEMENTATION SCHEDULE

Action	Estimated Completion Date
Commence construction.	November 1, 1982
Install four new monitoring wells (three downgradient and one upgradient).	Completed in May 1982
Install a slurry wall keyed into the underlying silt and clay stratum (or to a maximum depth of 30 feet) using construction borings to ensure that the wall is outside the farthest extent of the original pit area.	December 31, 1982
Move any surface or subsurface pockets of tarry petroleum sludge encountered in the areas immediately outside the pit during the slurry wall construction into the pit area.	December 31, 1982
Install a sand gas collection lens and cover the site with a fabric membracne to prevent upward migration of the tar.	July 2, 1983
Cover the membrane with a clay cap consisting or a minimum of 2 feet of clay compacted and keyed into the slurry wall.	July 2, 1983
Contour the clay cover to proved a slope of approximately 2 percent grade from the center to the edges. Install a vapor vent extending down to the membrane/sand lens.	July 2, 1983
Erect an effective barrier to vehicular traffic.	July 2, 1983
Post signs prohibiting vehicular traffic and prohibiting digging.	July 2, 1983
Provide a vegetative cover on a minimum of 6 inches topsoil to protect against erosion.	September 15, 1983

Source: Intergovernmental/Corporate Cooperation Agreement 1982

Groundwater Monitoring Wells

Six 4-inch (10-cm) groundwater monitoring wells were installed around the sludge pit during August 1981. In May 1982, four additional 4-inch (10-cm), multiple-depth monitoring wells were installed. The locations of all 10 monitoring wells are shown in Figure 10.

Hollow stem flight augers were used to drill holes to a depth of 25 feet (7.6 m) during the installation of the wells in August 1981. A reamer was used to enlarge the holes and 10-inch (25.4-cm) steel casing was placed in the holes to a depth of 21 feet (6.4 m). The hole was cleaned out using a rotary bit to a depth of 25 feet (7.6 m) and flushed with clean water. Four-inch (10-cm) PVC screened pipe with 0.010-inch (0.025-cm) slits was set at the desired depth. Sand was placed in the annual space between the 4-inch (10-cm) pipe and the casing was removed. The wells were then purged to remove all drilling remnants and the annular hole near the surface was sealed with a sand-bentonite mixture. A 6-inch (15-cm) steel pipe and cap with locking device was set in place, and a concrete seal cap was poured.

The details of the multiple depth wells, installed in May 1982, are shown in Figure 11.

Slurry Wall

300.70(b)(1)
(iii)(A)(1)
slurry wall

The final specifications for the slurry wall, submitted in July 1982, called for the construction of a soil bentonite slurry wall, which extended to a depth of about 30 feet (9.1 m) into the underlying low permeability silty clay around the 2326-foot (709-m) perimeter of the sludge pit (see Figure 10). Specifications called for the use of Wyoming-type bentonite, which conformed to American Petroleum Institute Spec 13A, Section 3, 5, 6, and 7, "Oil Well Drilling Fluid Material."

The preparation of the site for the installation of the slurry wall began in November 1982. Prior to initiating trenching, the slurry trench line was carefully staked to ensure that the adjacent 42-inch (107-cm) industrial drain and the 36-inch (91-cm) storm drain pipelines located south and north of the pit, respectively, would not be damaged during excavation.

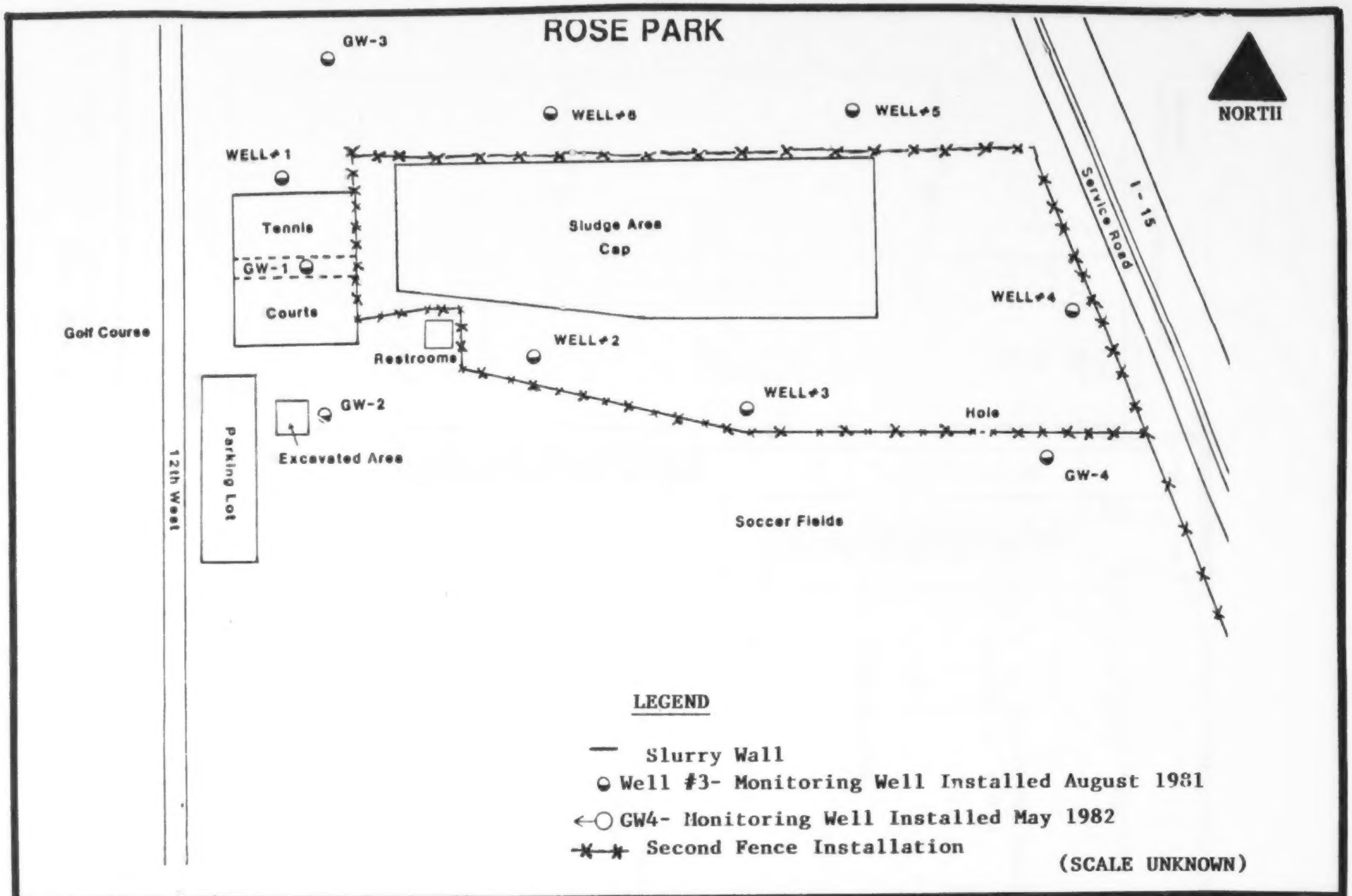


Figure 10. Location of Amoco Monitoring Wells, Rose Park Site, Salt Lake City, Utah

Source: Modified from Ecology & Environment 1983c

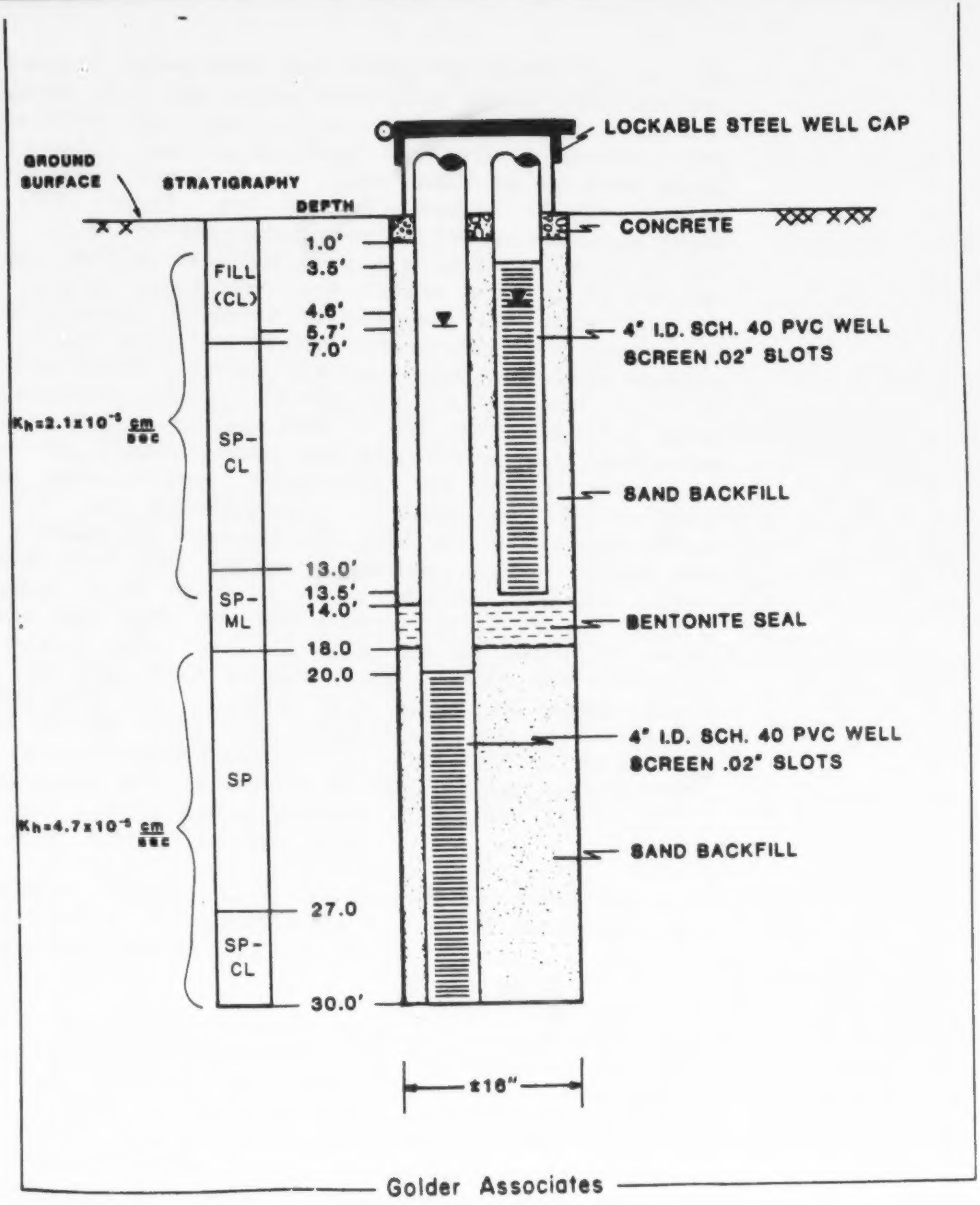


Figure 11. Schematic of Amoco's Multiple Depth Monitoring Well, Rose Park Site, Salt Lake City, Utah

Source: Golder Associates 1982c

Exploratory holes were dug along the north trench line to ensure that the storm sewer pipe was avoided and yet to maintain the trench line as far north as possible. Additionally, sprinkler lines for park irrigation were disconnected since these lines would be crossed along the east, south, and west boundaries of the slurry wall. Also, before excavation of the main trench began narrow, shallow trenches were dug on either side of the main trench centerline and filled with a bentonite-cement mixture intended to pregrout and stabilize the soil strata adjacent to the main trench. However, use of these small trenches did not prove effective because high moisture content in the surrounding soil kept the mixture from becoming firm. The soil in the upper strata was finely graded and pregrouting was determined to be unnecessary. Therefore, the use of the small trenches was discontinued. Excavation of the main trench began on December 15, 1982 and was completed on January 17, 1983 using a backhoe. The trench was excavated to a depth of about 30 feet (9.1 m). This allowed the wall to penetrate at least 10 to 15 feet (3.0-4.6 m) into the underlying low permeability clayey soil, 15 feet (4.6 m) below the lowest observed oily residue zone, and 10 feet (3 m) below the deepest known extent of the sludge pit. Soundings were made every 50 feet (15.3 m) along the trench centerline to detect any irregularity and to ensure an even trench bottom. The completed trench was a minimum of 2 feet (1 m) and a maximum of 5 feet (1.5 m) thick.

During excavation of the trench, any waste material encountered in or immediately outside of the trench was excavated and brought inside the enclosure.

Slurry was introduced into the trench directly after excavation. The quality of the initial slurry was checked for density and viscosity at least twice daily of the slurry in the trench was similarly checked for density and viscosity on a daily basis. The slurry in the trench was maintained at a density between about 65 and 80 pounds per cubic foot (1040-1280 kilograms per cubic meter) with the slurry at the bottom of the trench at the top of the backfill slope having a density of at least 15 pcf less than the backfill. The slurry was also maintained at a viscosity of no less than 40 seconds marsh funnel at 65 F. Bentonite content was kept to a minimum of 6 percent bentonite (dry weight). The purpose of maintaining the slurry within these specifications is to ensure that it can be displaced by the backfill, as well as to ensure that the trench remains open during excavation. Also, in order to maintain the open trench during excavation, the level of the slurry was usually maintained at no more than 1 to 2 feet (0.3 to 0.6 m) below the level of the graded or excavated surface immediately adjacent to the trench.

During excavation of the trench at the Rose Park site, a ruptured hydraulic hose and a broken tack drive mechanism kept the backhoe out of commission from December 21 to 26. During this period of inactivity, the level of the slurry in the trench dropped to about 4 or 5 feet (1.2 - 1.5 m) from the top, and the density decreased as some of the bentonite settled to the bottom. On December 27, a section of the wall along the southeastern perimeter of the trench sloughed off into the trench, probably as a result of the low level of the slurry. Since the centerline of the trench had been located only 10 feet (3.0 m) from the 42-inch (107-cm) industrial drain, loss of the wall threatened the stability of the soil surrounding the drain pipe. Therefore, this open span of the trench was immediately backfilled in order to prevent the loss of the drain pipe, which is only 9 feet (2.7 m) deep. To avoid a similar problem of having the trench cave in next to the storm drain line, the north wall of the trench was shifted 6 feet (1.8 m) south. During excavation of the new trench to the north, three 55-gallon (208-l) drums were encountered, as well as a great deal of debris and rubble. The drums were subsequently analyzed and found to contain wastes similar to those in the pit, but slightly more alkaline and having a higher boiling point. These drums were later disposed of in the pit. Also, in many places along the new north wall, tarry deposits were discovered in the top 5 to 6 feet (1.5-1.8 m) and were excavated and placed within the pit.

Backfilling was maintained at a minimum of 50 feet (15 m) and a maximum of 200 feet (61 m) behind the face of the excavation at the bottom of the trench. The backfill was composed of slurry and select soils obtained from the excavation and from an approved borrow source where the excavated material was not suitable. The backfill mixture was maintained at a minimum of 6 percent bentonite (dry weight). A number of quality control checks were made frequently on the backfill material. A gradation test and a density test were conducted every 300 feet (91 m) for the first week and every 600 feet (183 m) thereafter. The gradation test was performed to ensure that the percent fines were adequate to provide the final design permeability. Wet density tests were performed to ensure that the density of the backfill was adequate to displace the slurry. A slump cone test was also required at least three times a day or every 100 yd^3 (76 m^3). This test ensured that the backfill was wet enough to slump in the trench without trapping pockets of slurry, yet dry enough to displace the slurry easily.

For the most part, mixing of the backfill took place within the site, over the pit. However, the close proximity of the tennis courts on the west and the restrooms and the fence on the south dictated that backfill mixing be conducted inside the trench in this area. There were some instances where the mixing dozer came in contact with the underlying tarry sludge and mixing in that location had to be stopped. However, for the most part, the subfreezing weather kept the ground firm enough to allow mixing to occur without undue churning and pumping by the equipment. In an area along the northern side of the trench, excavated material was found to be unsuitable for backfilling and approximately 385 yd^3 (294 m^3) of clay material had to be imported from a nearby pit.

The backfill material was placed in an initial 45 degree sloping trench that was created at the start of excavation with a dozer pushing the prepared backfill at the trench starting point until the angle of repose was obtained. All of the remaining backfill was placed in such a manner that this natural angle of repose was maintained and no pockets of slurry were present in the complete trench. The backfill material was placed at the top of the trench and allowed to consolidate for a couple of weeks, after which a 1-foot (0.3-m) section of the consolidated top of the slurry trench was removed before proceeding with the construction of the cap. The final permeability of the slurry wall has been estimated to be -1.6-3.5 x 10^9 in-sec (4 to 9 x 10^9 cm-sec).

Construction of Sand Fill, Filter Fabric, and Clay Cover

The second phase of the remedial action involved the placement of a cover over the sludge pit. The components of the cover construction included the following: clearing and site grading; placement of bank run fill, clean sand fill, filter fabric, clay cover, and topsoil; and revegetation of the disposal area. A cross-section of the cap is shown in Figure 12.

300.70(b)(1)(ii) (C) grading

Site preparation, clearing, and grading prior to application of the cover materials began on April 26, 1983. Startup was delayed due to record rainfalls in March and in April. Prior to the placement of any cover material, it was necessary to locate the manholes from the storm drain along the northern boundary of the site. These manholes would later be extended upward.

The barrels of tarry waste that had been excavated during trenching were buried within the sludge pit area. Sludge pockets located outside the north and south wall were excavated and placed within the pit, and the excavated holes were filled with backfill material.

Rough grading of the site, using large dozers, progressed slowly due to continuing rain and wet conditions. Standing water, particularly in the southwest corner of the site, resulted in unstable work conditions and in heavy equipment getting stuck. In an effort to speed the drying process, wet material from the west end was spread over the dryer east end. Rainy conditions continued and a vacuum truck was finally brought in to pump standing water. A total of 22,000 gallons (83,270 l) of water, some containing oily residues, was pumped and deposited in an Amoco-owned settling pond. Rough grading then continued with a dozer and the required minimum 2 percent grade was verified using a laser level.

300.70(b)(1)(i) air emission controls

The next step was to lay the sand filter and one carbon-filter gas vent designed to provide a pathway through which gases can be vented in to the atmosphere. The gas vent pipe was laid approximately in the center of the site, and the entire pit including the vent pipe, was loosely covered with 1 foot (0.3 m) of sand to a 2 percent grade from the center to the perimeter of the site. Gradation tests conducted on the sand fill showed that less than 3 percent of the material passed the 200 sieve. Approximately 8530 yd^3 ($6522m^3$) of sand fill were laid.

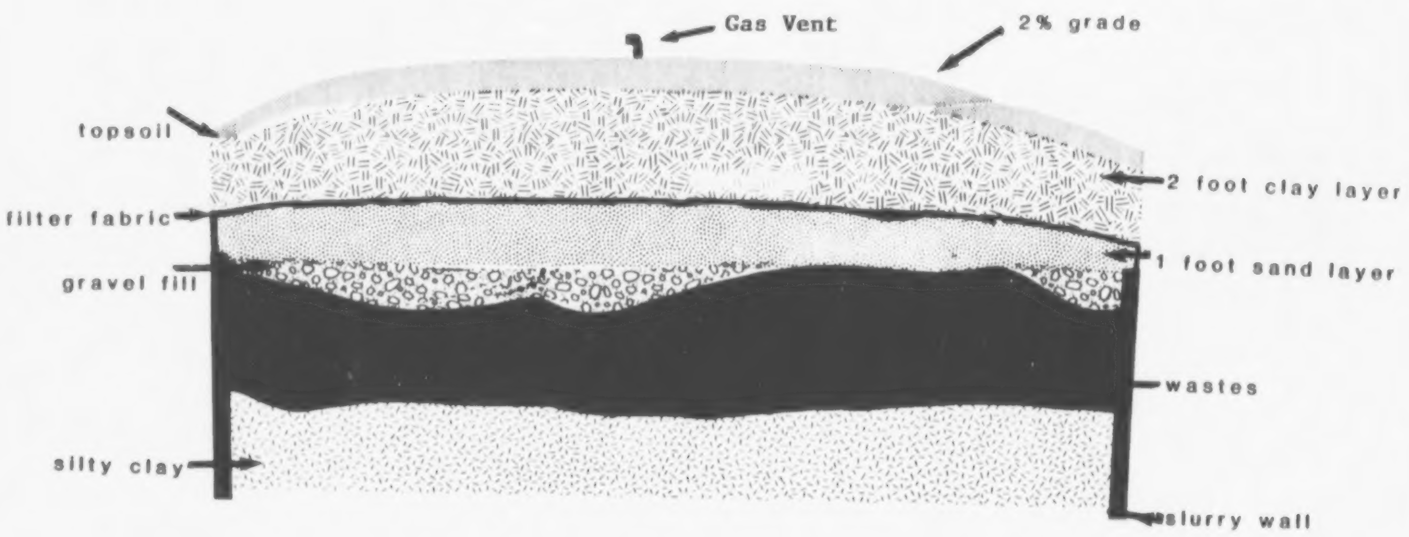


Figure 12. Cross Section of Disposal Area with Clay Cap, Rose Park Site, Salt Lake City, Utah

Source: Based on Golder Associates 1982b

The next step was to place the filter fabric, Amoco's "Propex 2006" civil engineering fabric, loosely over the sand fill. The purpose of the filter fabric was twofold. First, it was intended to help stabilize the underlying material, and secondly, it was intended to prevent upward migration of the sludge during hot periods of the year. A key way was dug for the filter fabric to tie into, the fabric rolls were loosely laid, and the joints were sewed so as to provide a minimum overlap of 3 inches (7.6 cm). The fabric membrane covers an area of approximately 25,580^2 yd (21,387 m^2) or 5.25 acres (2.12 ha).

Since the filter fabric is subject to deterioration by ultraviolet light, it was protected from sunlight during storage and was covered with the clay cover material within one week of application.

300.70(b)(1)(ii)
(A) surface seals

The material used for the 2-foot (0.6-m) thick clay cap consisted of a relatively wet tan silt with some clay and some medium to fine sand. Quality control tests of the material showed it to have low permeability and low shrinkage. Pertinent engineering characteristics of the cover material include:

- Moisture content:

  25.4% as received
  17.5% optimum

- Maximum dry density (ASTM-D698):

  107.5 psf

- Shrinkage limit:

  16.8%

- Atterberg limit:

  Non-plastic

- Grain size distribution:

  Sand - 33%

  Silt - 57%

  Clay - 10%

- Permeability (94% of maximum dry density):

  $3.5 - 5.29 \times 10^{-7}$ cm/sec.

- pH: 9.6

Source: Golder Associates, Inc. 1982a.

The cover material was spread in the direction of the fabric overlap, taking care to protect the integrity of the filter fabric. Grading of the site to a 2 percent grade was accomplished with a dozer and laser level, with some finish grading being done by a rubber tire grader. The cover was compacted to more than 90 percent of maximum density using a sheepsfoot roller and a steel drum roller for final compaction. Compaction was determined by the use of a nuclear density meter. Test results indicated that the final permeability of the cap ranged from 1.9×10^{-10} to 1.3×10^{-9} ft/sec (6×10^{-7} to 4×10^{-8} cm/sec).

The cap was then covered with 8 inches (20 cm) of topsoil. This work was completed on July 22, 1983. The decision was made to postpone revegetation until the weather was cooler during the following spring season so that the seed would have a better chance for growth. Seed was finally planted in late spring 1984, and consisted of a mixture of wheat grasses that require little water.

300.70(b)(1)(ii)
(D) revegetation

Site Security Measures

Prior to vacating the site in July 1984, the chain-link fences to the north of the site, which had been removed at the start of the trenching operation, were reinstalled.

Two manholes, one located along the northern boundary and one located in the southwest corner of the area, were extended upward with reinforced, cast-in-place concrete.

A vehicular barrier was erected in October 1984. The barrier is a corrugated steel rail mounted on steel posts and stands about 3 feet (0.91 m) high. It runs along the west, south, and east sides, butting into the chain-link fences on the north. Warning signs have been placed at each entrance to the containment area prohibiting digging or vehicular traffic.

COST AND FUNDING

Source of Funding

All project costs were paid by Amoco Oil Company. The Intergovernmental/Corporate Cooperative Agreement stipulates that 50 percent of the trust fund to cover the cost of the implementation of the monitoring program is to be contributed by Salt Lake City, and 50 percent by Amoco. Costs of maintenance of the site after project closeout are the responsibility of the City, since the City owns the property.

300.68(c) responsible party clean-up

Selection of Contractors

Both EPA and Amoco retained contractors to carry out the activities associated with the site investigation and the remedial action.

Fred C. Hart Associates was initially called upon in 1979 through the EPA Region VIII Technical Assistance Panels Program to conduct a field investigation and to evaluate remedial alternatives. From June 1980 through January 1982, Fred C. Hart Associates continued to provide technical services to EPA as a subcontractor to Ecology and Environment, the FIT prime contractor. Additional field investigations were undertaken, samples were collected and analyzed from Amoco-installed monitoring wells, and a report was prepared that evaluated Amoco's proposed remedial action along with other remedial alternatives.

Fred C. Hart Associates also engaged a number of subcontractors under the FIT program. Applied Geophsics of Salt Lake City conducted an electrical resistivity survey of the site in October 1980, and Technos Inc. of Miami, Florida provided a geophysical survey using ground penetrating radar and electromagnetic surveying equipment. Several laboratories were involved in chemical analysis and soil testing, including Rocky Mountain Analytical Lab, West Coast Technical Services Company, California Analytical Labs, Chen and Associates, and Versar.

Following initiation of the remedial action by Amocc, Ecology and Environment became involved under the FIT contract. Ecology and Environment's activities included quarterly sampling of groundwater monitoring wells for the first year following completion of the slurry wall and clay cap; evaluation of Amoco's proposed revegetation plan; and preparation of the site "NCP Deletion Recommendation Package."

Amoco retained the services of Golder Associates of Lakewood, Colorado to prepare specifications for the slurry well and the clay cap. Amoco then screened potential contractors based on their experience in slurry wall construction and extended an invitation to bid to the three most highly qualified firms. Soletanche and Rodio, Inc. of McLean, Virginia was selected as the prime contractor based on their extensive experience in slurry wall construction. Soletanche and Rodio, in turn, subcontracted the construction of the clay cap to Moulton Excavation of West Jordan, Utah. Rollins, Brown and Gunnel, Inc. of Provo, Utah installed groundwater monitoring wells and Roberts and Sons of Salt Lake City emplaced the vehicular barrier. The U.S. Army Corps of Engineers, Utah Resident Office, oversaw the construction activities performed by Amoco's contractors.

All contractor fees to Amoco were lump sum bids, and are itemized in Table 10. No other cost information on remedial actions at the site was available. The trust fund for monitoring the groundwater at the site totals $90,000, the principal of which was paid equally by Salt Lake City and Amoco.

PERFORMANCE EVALUATION

All available information indicates that the remedial actions undertaken at the Rose Park Sludge Pit were carried out according to specifications and have been successful in meeting the objectives as stated in the Intergovernmental/Corporate Cooperation Agreement.

The clay cap, with its permeability generally estimated at less than 1.3×10^{-9} ft/sec (4×10^{-8} cm/sec), greatly minimizes the threat of direct contact. It has also been successful in eliminating nuisance odors, which were a concern of residents living near the sludge pit.

TABLE 10. COST OF INVESTIGATION AND REMEDIAL WORK AT ROSE PARK

Item	Approximate Dimensions	Actual Expenditure	Unit Cost	Approximate Date of Performance
Monitoring Wells	9 wells & repairs to 3	$11,000	$1,222/well	n/a*
Consultant Fees	n/a	70,000 (1)	n/a	n/a
Slurry Wall 2% Soil-Bentonite Mix	3 x 30 x 2363 ft (.6 x 9.1 x 720 m)	311,000	4.35/ft^3 (47.24/m3)	12/15/82 to 1/17/83
Rough Grading	30,100 yd^2 (25,167 m^2)	47,000	1.56/yd^2 1.87./m^2	4/26/83 to 7/5/83
Sand	1 ft x 26,340 yd^2 (.30 m x 22,024 m^2)	63,000	7.18/yd^3 (9.39/m^3)	6/1/83 to 6/30/83
Clay	2 ft x 30,100 yd^2 (.61 m x 25,167 m^2)	203,000	10,12/yd^2 (13.23/m^3)	6/15/83 to 7/22/83
Fabric	26,340 yd^2 (22,024 m^2)	62.000	2.351/yd^2 (2.81/m^2)	6/1/83 to 7/15/83
Topsoil	8 in. x 30,100 yd^2 (.02 m x 25,167 m^2)	60,000 (2)	8.97/yd^3 (11.73.m^3)	7/15/83 to 7/30/83
Seeding	30,100 yd^2 (25,167 m^2)	10,000 (3)	0.33/yd^2 0.40/m^2	5/1/84 to 5/15/84
Gas Vent	1	3,000	3,000/vent	6/1/83 to 7/1/83
Sprinkler Work (Removal Repair, and Replacement)	n/a	2,000	n/a	6/1/83 to 5/13/84
Guard Rail	1415 feet	17,000	$12.01/ft	10/1/83 to 10/15/83

(continued)

(1) Increases in cost from the estimated $47,000 due to changes in scope, unexpected mapping, sampling, and testing.

(2) Increase in cost from the estimated $45,000 due to increasing depth of topsoil from 6" to 8".

(3) Increase in cost from the estimated $7,000 due to unanticipated final site grading.

* N/A indicates information not available

** Information presented in Table 10 was provided via courtesy of John Huddle, Amoco Oil Company

TABLE 10. (CONTINUED)

Item	Approximate Dimensions	Actual Expenditure	Unit Cost	Approximate Date of Performance
Fence Work (Removal Repair, and Replacement)	n/a	$4,000	n/a	11/15/82 to 7/30/83
Site Restoration	n/a	22,000	n/a	n/a
Miscellaneous (Signs, Shipping, etc.)	n/a	1,000	n/a	n/a
In-House Costs (Coordination, Sampling, Testing, and Management	n/a	318,000	n/a	n/a
Total Cost, Excluding In-House Costs		8,886,000		
Total Cost, Including In-House Costs		1,204,000		

In addition, construction of the containment system (slurry wall and cap) has seemingly minimized the potential for future groundwater contamination by providing a hydrologic barrier to migration of contaminated groundwater in and out of the pit and infiltration of precipitation into the pit. (It should be pointed out that groundwater contamination was not an immediate concern at the site.) However, the naturally low permeability of the soil, and the tendency of the materials themselves (tars and sulfonated tars) to cohere, will continue to retard movement of the sludge from the pit.

Both EPA personnel and the FIT contractor suggested that capping alone may have been adequate at the Rose Park site. However, based on several meetings held between Amoco and the community representatives, Amoco chose the more comprehensive plan so that it could minimize any further liability and mitigate existing fears of the community about the site. This is a case where the community clearly influenced the final selection of the remedial stategy.

The results of FIT's 1983 quarterly sampling show that there are high background levels of total organic carbon (TOC) and total organic halogen (TOX) in the groundwater surrounding the site. TOC concentrations range from 5.1 to 9.4 ppm (mg/l) and TOX concentrations range from 0.5 to 1 ppm (mg/l). However, analysis shows that no organic priority pollutants are present in the groundwater and that there are no significant occurrences or trends in the levels of inorganic priority pollutants.

Background levels of organic matter (TOC) are generally high outside of the pit. High levels of TOC and TOX may be related to several other sources, including a nearby oil company pipeline corridor which has had spills in the past, abandoned and filled sewage canals, and dirt fill brought in from other areas. This, in addition to the presence of high amounts of dissolved salts, may limit the efficiency of the groundwater monitoring program.

Overall, the containment system appears to be an effective long-term solution to the problems encountered at the Rose Park Sludge Pit.

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TACOMA WELL 12A
TACOMA, WASHINGTON

INTRODUCTION

NCP Reference

The City of Tacoma, Washington, owns and operates 13 high-yield supply wells in the South Tacoma Channel, adjacent to Commencement Bay. (Initially the South Tacoma Channel was included with several other sites as part of the Commencement Bay Superfund site, see Figure 1.) This well field supplies water required to meet peak summer demand for Tacoma, and operation is usually required for only several months in late summer and early autumn. Well 12A, the northernmost well in the field, was taken out of service in 1981 after analysis of samples identified chlorinated organic solvents in the groundwater. Additional sampling indicated the source was located somewhere north of Well 12A. Furthermore, the spreading of contaminants to other wells after Well 12A was taken out of service showed that further contamination of the well field could be prevented if Well 12A remained in service to act as a barrier. A feasibility study, begun in late 1982, recommended that air-stripping be conducted at the well head to remove volatile organics from Well 12A groundwater--the most cost-effective interim remedial action. The system, consisting of five air-stripping towers each capable of treating 700 gallons per minute (2,650 l/min), was started in August 1983--the same time that the EPA discovered an area northeast of the site which could be a major contributor of contaminants to the plume. As of October 1983, the system was removing 98 percent of the volatiles present in Well 12A groundwater.

Background

Contamination of the aquifer underlying the South Tacoma Channel was first detected when the National Organics Monitoring Survey, conducted in March 1976, discovered traces of trichloroethylene in Tacoma well water. Following the publication of the survey results in 1978, an investigation was initiated to identify potential sources of this contaminant (Tacoma DPU 1984a).

300.63(a)(2)
government

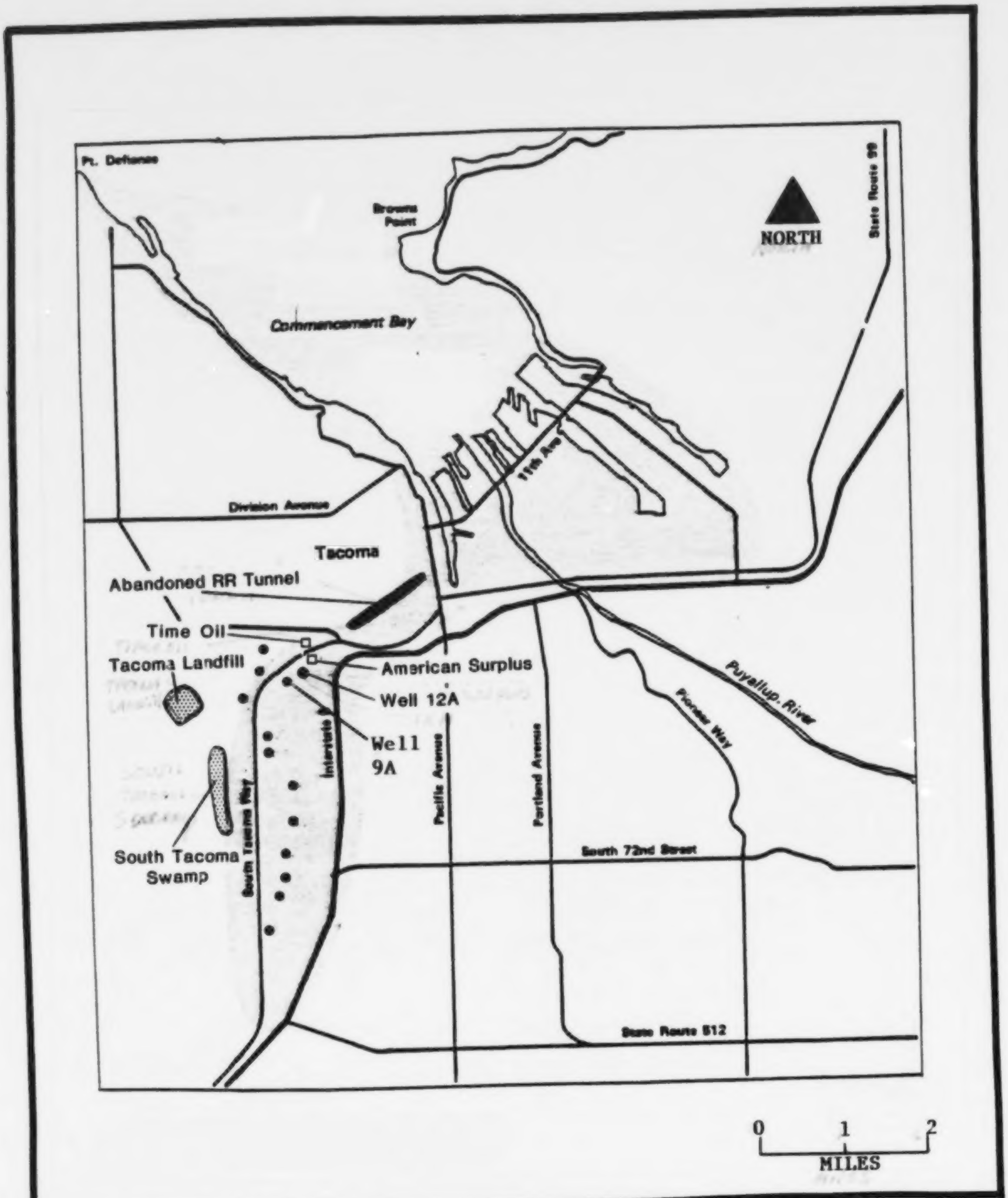


Figure 1. South Tacoma Channel Area - Well 12A Area

Source: USEPA 1982

USEPA: 1982

Figure 1: South Tacoma Channel Well 12A Area

After several possible sources were examined, the Department of Ecology and the Tacoma-Pierce County Health Department discovered several thousand chemical containers at the American Surplus site in July 1981. Although it was later confirmed that this site was not the source of contaminants in Well 12A, its proximity to Well 12A prompted the testing of water from 12A.

investigation

Well 12A, which produced 3500 gallons per minute (13,250 l/min), was used in conjunction with 12 other wells to provide supplemental water during high-usage months. Results from initial testing showed significant contamination and indicated the need for further testing of this and other wells in the field. The EPA and the Department of Ecology took groundwater samples from Well 12A and other wells on July 24, August 21, August 27, and September 15, 1981. The ranges of concentrations of the pollutants found in these samples are:

300.62(a)
state role

300.68(e)(1)
(iii)
contaminated
drinking water

• 1,1,2,2 tetrachloroethane	17 to 300 ppb (ug/l)
• 1,2 trans-dichloroethylene	30 to 100 ppb (ug/l)
• trichloroethylene	54 to 130 ppb (ug/l)
• tetrachloroethylene	1.6 to 5.4 ppb (ug/l).

The concentrations of these pollutants decreased in samples of Well 12A water in the following year, when the well was not in service. However, contaminants began showing up in other wells, notably in Well 9A located about 1000 ft (304m) southwest of Well 12A (see Figure 1). This fact, combined with information from monitoring wells installed during the remedial investigation, indicated that the contaminated plume was migrating to other wells in the absence of the pumping of Well 12A. The remedial investigation/feasibility study, finished in 1983, did not identify the source of contamination. Further work to determine the source was undertaken by the EPA, its Field Investigation Team (FIT), the Department of Ecology, and the County Health Department.

At the time of this writing, results of these efforts indicated that the source of contamination may have been waste filtrate sludges from oil reclamation processes practiced by a company (now bankrupt) that formerly leased the land next to a railroad spur.

Because of the need for potable water in summer months, a need that could not be met by simple conservation measures, it was decided that abandoning the well field was not a viable option. Further, it was decided that an initial remedial measure was necessary to contain the contaminated plume and to provide safe drinking water for the people of Tacoma until a more permanent solution

300.68(e)(1)
initial remedial
measure

could be found. On March 10, 1983, a public meeting was held in the Tacoma-Pierce County Health Department to discuss the proposed initial remedial measure (IRM). Public comment was solicited and information concerning the proposed action was made available in public information repositories.

Synopsis of Site Response

Pumping and treatment of the water from Well 12A was the selected response to the problem of keeping the well operating to act as a barrier to contaminant migration. The FIT determined that withdrawing water at a rate above 2000 gpm (7570 l/min) would halt the contaminant migration to other wells. However, the pumping rate had to be maintained at 3500 gpm (13,250 l/min) due to complications involved in altering the pumping rate. Five forced-draft stripping towers were installed to remove the volatile organic compounds (VOCs) from the water. The towers, standing approximately 50 ft (15 m) tall, were first started August 2, 1983, and then brought on-line 2 days later. They were operated for 3 months in 1983, and removed approximately 98 percent of the VOCs from the water. The treated water was then piped to the Hood Street Reservoir, where it was mixed with uncontaminated water before entering the distribution system.

300.65(b)(7)
barriers to deter
spread of release

300.70(b)(1)(iii)
(c)
groundwater
pumping
300.70(b)(2)(ii)
(c)(1)
air stripping

The treated water met the established guideline maximum concentration level, risk level for VOCs of one case per 1 million people (see Extent of Site Response section). Operational lifetime of the IRM is 5 years.

The Record of Decision for the remedial action selection states "...off-site disposal is more cost-effective than potential on-site remedies" (USEPA, 1983b). The discharge of VOCs into the air is considered to be off-site disposal, although it is dissimilar from many other off-site disposal methods insofar as the contaminants are not contained. Specifications of the design set atmospheric discharge levels at 39.9 lbs (18.1 kg) of VOCs per day. Worst-case scenarios for concentrations of the VOCs on the ground described levels of VOCs which were 3 to 6 orders of magnitude below 8-hour OSHA standards for the four chemicals of primary concern.

The process, when first implemented, was considered to be a relatively new innovation in potable water treatment. Beause little was known about actual removal rates, pilot studies were required to determine removal rates of the organic contaminants in Tacoma well water before the full-scale version was designed. Although the design removal rate is 88 percent, the system has removed about 98 percent of the total VOCs in 12A water.

SITE DESCRIPTION

Surface Characteristics

The South Tacoma Channel area has been the center for a variety of industrial activities for over 100 years. The area has been used for:

- Manufacturing, industrial, and military waste disposal
- Heavy equipment rebuilding and cleaning
- Railroad repair and loading
- Waste oil refining
- Hazardous materials storage
- Miscellaneous other industrial activities.

Several known or suspected disposal sites are in the area:

- An abandoned railroad tunnel that funnels groundwater from the South Tacoma Channel area; the tunnel was only recently cleared as a potential site of hazardous waste disposal.
- The South Tacoma swamp has been filled with industrial wastes, reportedly including drums containing unknown waste types, and has been the site of spills, degreasing, and draining operations; emptying of transformers; and railroad car demolition.
- The City of Tacoma Sanitary Landfill is believed to have been used for the disposal of hazardous waste.
- The American Surplus Sales Company, a known disposal site, has been a surplus materials handling company for 40 years, and many types of hazardous materials have been spilled at the 3-acre (1.2-ha) site.

- EPA investigations aimed at discovering the source of Well 12A contamination identified a site (Time Oil) northeast of 12A where high concentrations have been found of the same compounds that are contaminating Tacoma groundwater (see Figure 1).

300.64(A)(2)
identification
of source and
nature of
release

Topography in the area has been altered by at least four glacial advances during the Pleistocine (1.2 million to 11,000 years before present). These ice sheets deposited a variety of till, outwash sand, gravel and glacial lake sediments, and scoured valleys by both glacial and fluvial action. Well 12A is located atop a bluff overlooking one such valley--the South Tacoma Channel. This valley merges through an outwash valley with tideflat areas along Commencement Bay to the northeast. These tideflats once formed the Delta of the Puyallup River, but the flats have been filled and streams have been channelized as more industries moved to the area.

Tacoma's climate is moderate. Table 1 provides temperature and precipitation data for the Seattle-Tacoma area.

300.67(c)(6)
weather
300.68(e)(2)(i)
(E)
climate

Hydrogeology

The South Tacoma Channel area lies in the Puget Lowlands, an area consisting of thick, complex sequences of glacial deposits laid down in Holocene (recent), Pleistocine (up to 2 million years before present [MYBP]), and Late Tertiary (2 to 26 MYBP) times. These deposits of clay, silt, sand, gravel, and glacial till partly fill a large, north to south trending structural basin known as the Puget Trough. Permeability within these deposits varies widely, with values typically ranging between 3.3×10^{-3} and 3.3×10^{-8} ft/sec (1×10^{-2} and 1×10^{-7} cm/sec).

300.68(e)(2)(i)
(D)
hydrogeological
factors

Aquifers of interest in the immediate area of Well 12A consist of recent alluvial deposits and underlying Pleistocene age till and outwash deposits. Meltwater, streams flowing from east to west across the area deposited these outwash sands and gravels during advances and retreats of the Vashon and Salmon Spring glaciers. Stratigraphic correlation of these highly varied and complex sequences is difficult.

Analysis of well and boring logs identify Pleistocene deposits to a depth of approximately 200 ft (61 m) below

TABLE 1. TEMPERATURE AND PRECIPITATION DATA FOR THE SEATTLE-TACOMA AREA

	Temperature (°F - °C)					Precipitation (in. - cm)		Wind			Relative Humidity	
	Normal Maximum	Normal Minimum	Normal Average	High	Low	Normal Total	# Days .01 Inch PPT or More	Prevailing Direction (from)	Mean Speed MPH (MPH-KMH)	Fastest Wind Speed and Direction (MPH-KMH)	Low %	High %
January	44-6.6	33-0.5	38-3.3	67-19.4	3-(-)16.1	4.5-11.4	18	South	8-12.9	Southwest, 63-111.0	73	85
February	47-8.3	35-1.6	41-5.0	70-21.1	4-(-)15.6	3.9-9.9	16	South	8-12.9	South, 68-109.4	--	--
March	51-10.5	36-2.2	44-6.6	81-27.2	20-(-)6.7	3.0-7.6	16	South	9-14.5	Southwest, 60-96.5	--	--
April	58-14.4	41-5.0	49-9.4	87-30.5	30-(-)1.1	1.8-4.6	13	South	8-12.9	South, 65-104.6	52	85
May	66-18.9	45-7.2	56-13.3	92-33.3	35-1.6	1.6-4.1	12	South	8-12.9	Southwest, 45-72.4	--	--
June	70-21	50-10.0	60-15.5	100-37.8	40-4.4	1.4-3.6	9	South	8-12.9	Southwest, 54-86.9	--	--
July	76-24	54-12.2	65-18.3	100-37.8	46-7.8	0.5-1.3	5	North	7-11.3	Southwest, 38-61.1	46	85
August	75-24	54-12.2	64-17.8	97-36.1	46-7.8	0.9-2.3	5	North	7-11.3	Southwest, 35-56.3	--	--
September	69-20.5	51-10.5	60-15.5	92-33.3	36-2.2	1.5-3.8	8	Southeast	6-9.7	Southwest, 55-88.5	--	--
October	60-15.5	44-6.6	52-11.1	82-27.8	29-(-)1.7	30-76.2	13	Southeast	7-11.3	South, 63-111.0	68	91
November	50-10.0	38-3.3	44-6.6	70-21.1	13-(-)10.6	4.6-11.7	18	Southeast	6-9.7	Southwest, 57-91.7	--	--
December	46-7.8	36-2.2	41-5.0	65-18.3	12-(-)11.1	6.3-13.5	19	Southeast	8-12.9	Southwest, 60-96.5	--	--

Source: Climatic Atlas of the United States land surface in the Well 12A area. The three types of hydrogeologic units encountered include:

- Highly permeable, predominantly gravel strata (high permeability)
- Less permeable sand and silt units (intermediate permeability)
- Low permeability units with a high proportion of silt and clay (low permeability).

Geologic cross-sections developed from data collected during remedial investigations in the area are shown in Figures 2 and 3.

Investigations identified five major geologic features that impact upon groundwater flow in the area:

300.66(c)(2)
(iii)
assessing migration potential

1. A high permeability unit occurring at an elevation between 150 and 200 ft (46 to 61 m) mean sea level (MSL) which appears to be somewhat continuous over the study area. (Well 12A is screened in this unit.)
2. High permeability units occurring both above and below the 150 to 200 ft (40 to 61 m) units but which do not appear to be continuous across the study area.
3. Intermediate- and low-permeability units separating the high permeability layers.
4. A thick, extensive, intermediate permeability unit continuous across the study area and with a hydraulic conductivity estimated to be from 2 to 4 orders of magnitude lower than the high permeability units. This unit occurs between low permeability units but above the high permeability unit located at 150 to 200 ft (45.7-60.9 m) MSL.
5. A thin, apparently noncontinuous low-permeability unit (high silt and clay content) underlying the high permeability units and with a hydraulic conductivity estimated to be from 5 to 8 orders of magnitude lower than the high permeability units.

Although these geologic features affect groundwater and contaminant flow by creating preferential migration paths and flow boundaries, direction of groundwater flow

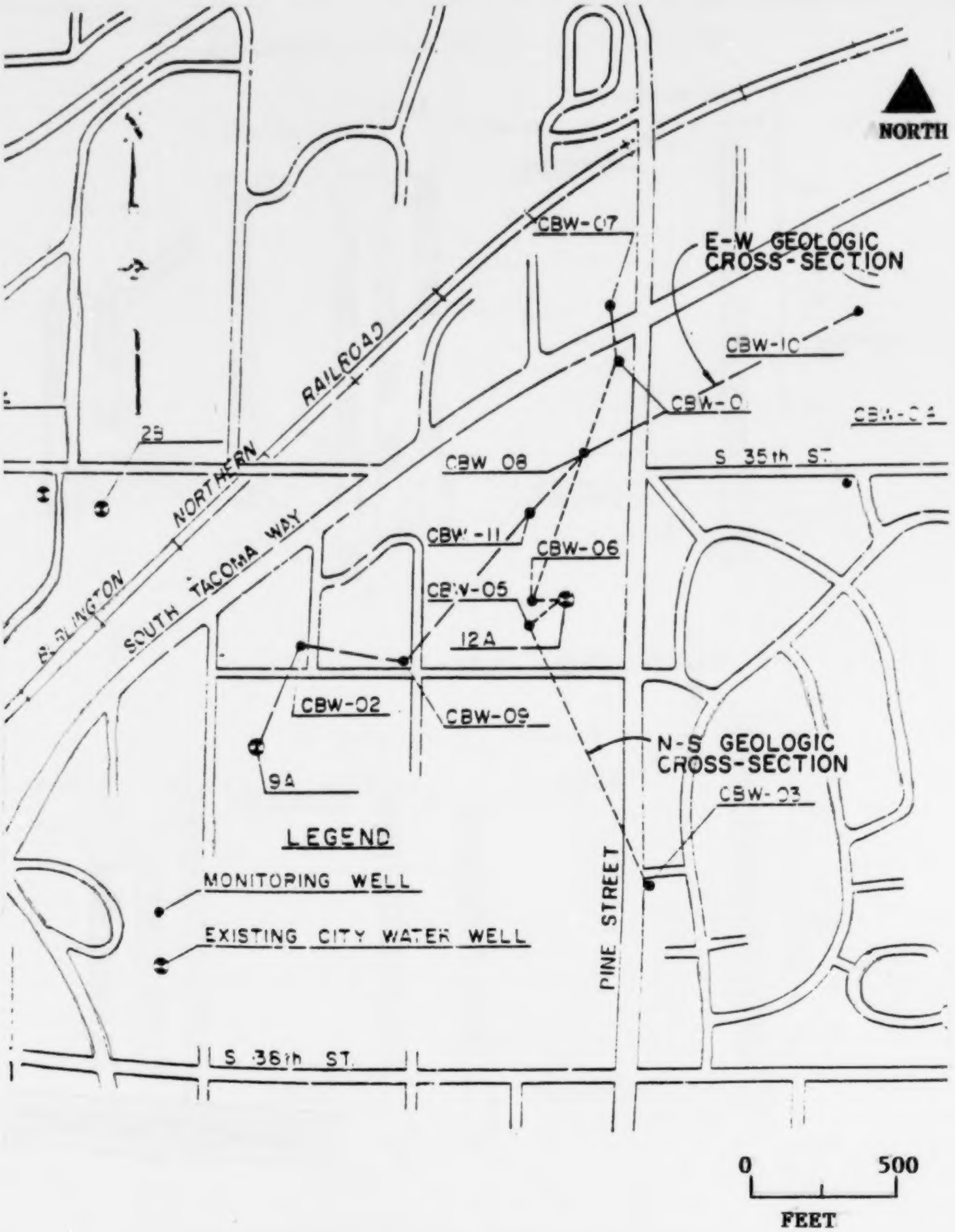


Figure 2. Areal Location of Geologic Cross-Section Plot Points

Source: Black & Veatch 1983d

Geologic
Figure 2: ~~CROSS-SECTION~~ AREAL LOCATION OF CROSS-SECTION PLOT POINTS

SOURCE:

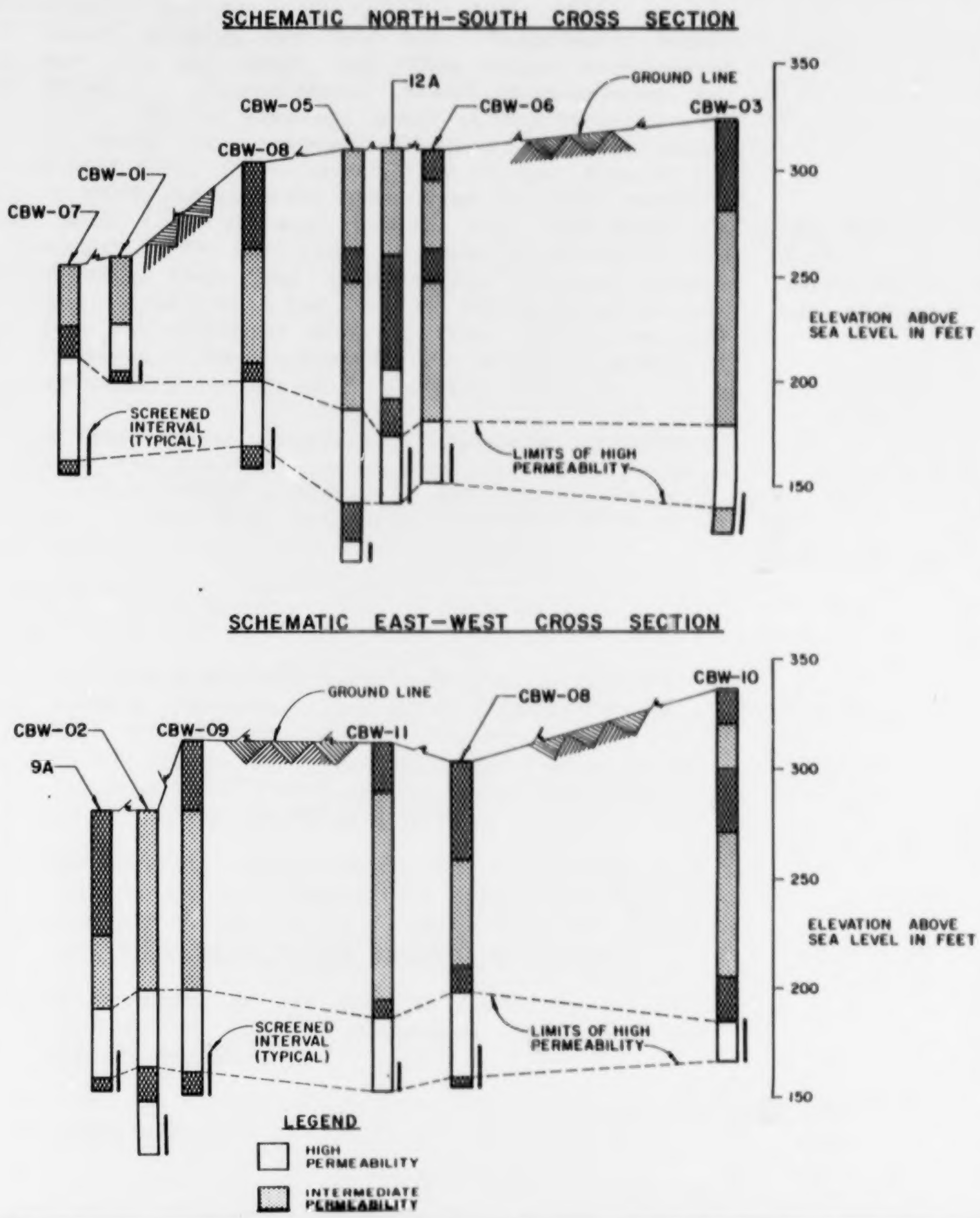

SCHEMATIC NORTH-SOUTH CROSS SECTION
CBW-07
CBW-01
CBW-08
CBW-05
12A
CBW-06
GROUND LINE
CBW-03
SCREENED INTERVAL (TYPICAL)
LIMITS OF HIGH PERMEABILITY
350
300
250
200
150
ELEVATION ABOVE SEA LEVEL IN FEET
SCHEMATIC EAST-WEST CROSS SECTION
CBW-02
9A
CBW-09
GROUND LINE
CBW-11
CBW-08
CBW-10
SCREENED INTERVAL (TYPICAL)
LIMITS OF HIGH PERMEABILITY
350
300
250
200
150
ELEVATION ABOVE SEA LEVEL IN FEET
LEGEND
HIGH PERMEABILITY
INTERMEDIATE PERMEABILITY

Figure 3. **Geologic Cross-Section and Relative Permeabilities in the Well 12A Area**

Source: Black & Veatch 1983d

Figure 3: Geologic Cross-Sections of Well-12A Area

Source:

in the area is controlled primarily by the seasonal pumping of the well field. The undisturbed, steady-state potentiometric surface in the area is flat, with a groundwater divide existing near Well 12A. Groundwater enters this area from the south, and flows either west toward Puget Sound or east-northeast toward Commencement Bay (Figure 4). During pumping, cones of depression around each well result in a reversal of groundwater flow northeast of Well 12A. Direction of flow changes from northeasterly under steady-state conditions to south easterly toward Well 12A. If Well 12A is shut down while the the remainder of the well field remains in operation, the combined well field cone of depression reverses groundwater flow direction in the area and contaminated groundwater from the northeast quadrant flows toward the well field. Figures 5 and 6 illustrate the estimated effect of operating Wells 9 and 12A on groundwater flow.

300.66(c)(2)
(iii)
assessing migration potential

One final factor potentially influencing groundwater and contaminant flow in the area is the existence of a slight downward vertical hydraulic gradient in the area. Over time, a vertical hydraulic gradient could drive contaminants downward toward uncontaminated aquifers.

The hydrogeology of the area around Tacoma Well 12A can be summarized as follows:

- Subsurface deposits consist of glacial deposits of varying thicknesses and areal extent; however, a high permeability unit (150 to 200 ft MSL [46 to 61 m]) and an underlying apparently noncontinuous low permeability unit appear to be most important in evaluating contaminant flow.
- Steady-state groundwater flow is toward the northeast in the area immediately adjacent to Well 12A when the wells are not in operation, but flow is toward the wells during pumping operations.
- Stratigraphy in the area is confused, primarily because of complex sequences of interbedded glacial deposits.

WASTE DISPOSAL HISTORY

The source of contamination of Tacoma groundwater was unknown at the time the implementation of the initial remedial measure began. By September 1983, a deposit of filter cake, 2.5 feet (.76 m) high, 25 feet (7.6 m) wide and several hundred yards in length, had been found along a railroad spur in the vicinity of Time Oil Company (see

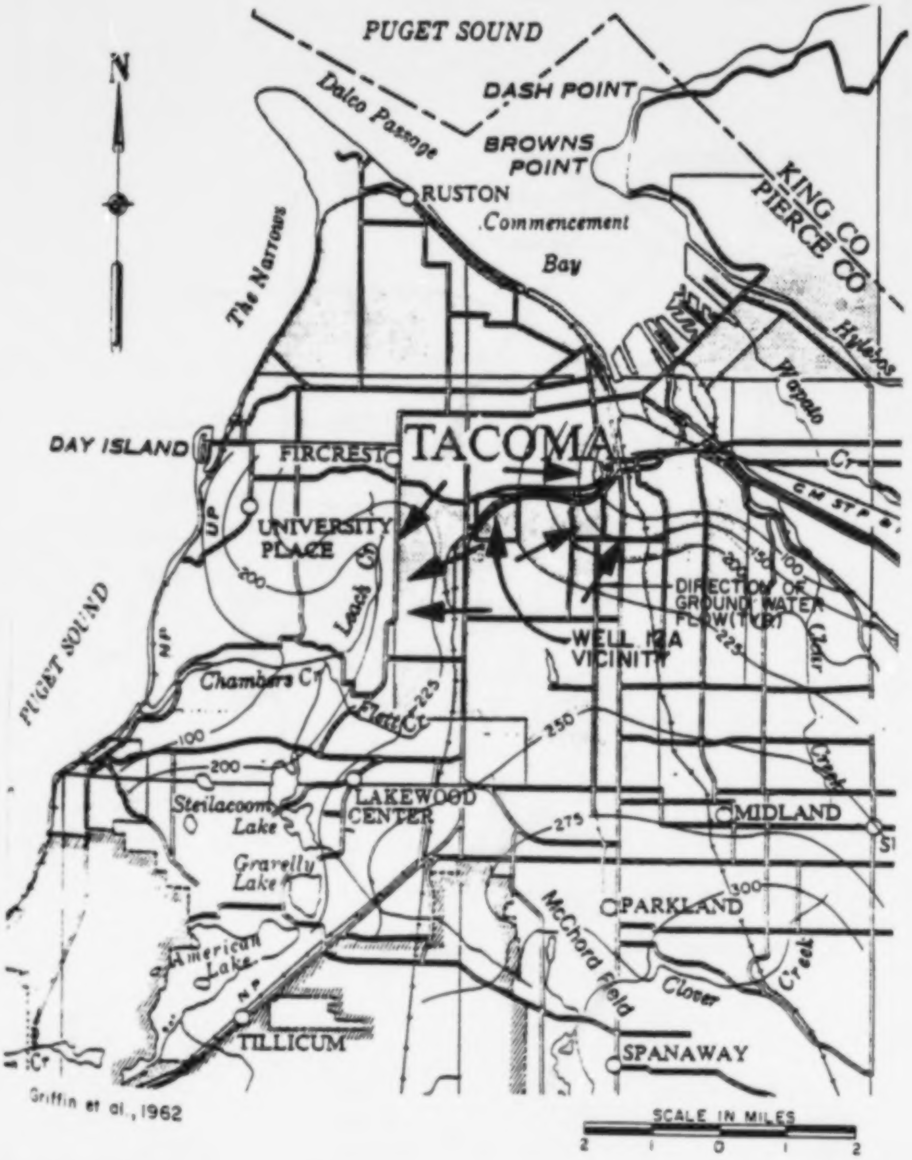


Figure 4. Undisturbed Steady State Flow Patterns - Well 12A Area

Source: Black & Veatch 1983d

Figure 4: UNDISTURBED STEADY STATE F PATTERNS - 12A AREA
SOURCE:

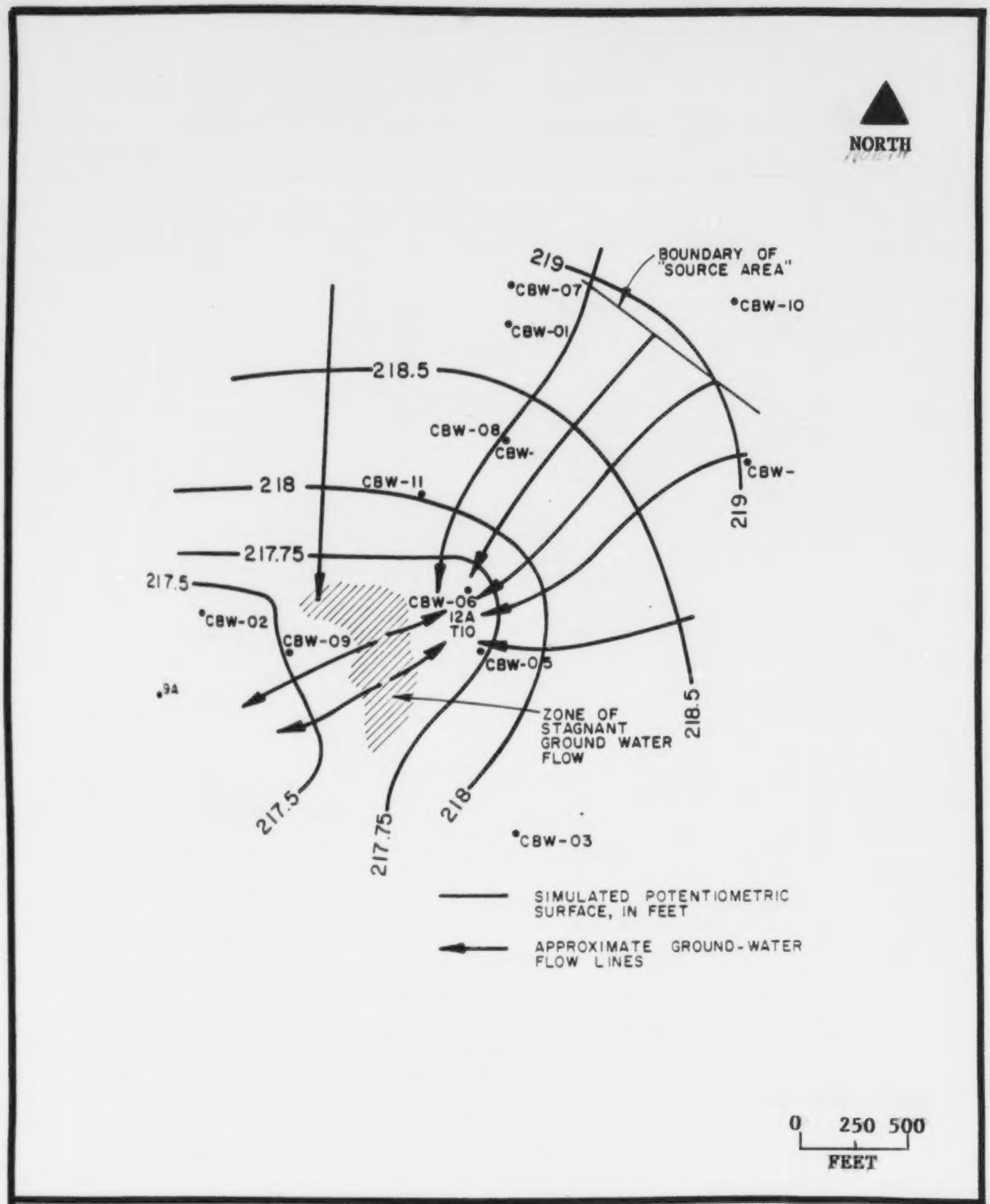


Figure 5. Model of Groundwater Flow Patterns - Well 12A = 1500 gpm, Well 9A = 3300 gpm, Well 11A* = 5000 gpm

* Well 11A not identified here because its location is beyond the area shown, however, its pumpage was part of model conditions.

Source: Black & Veatch 1983d

Source:

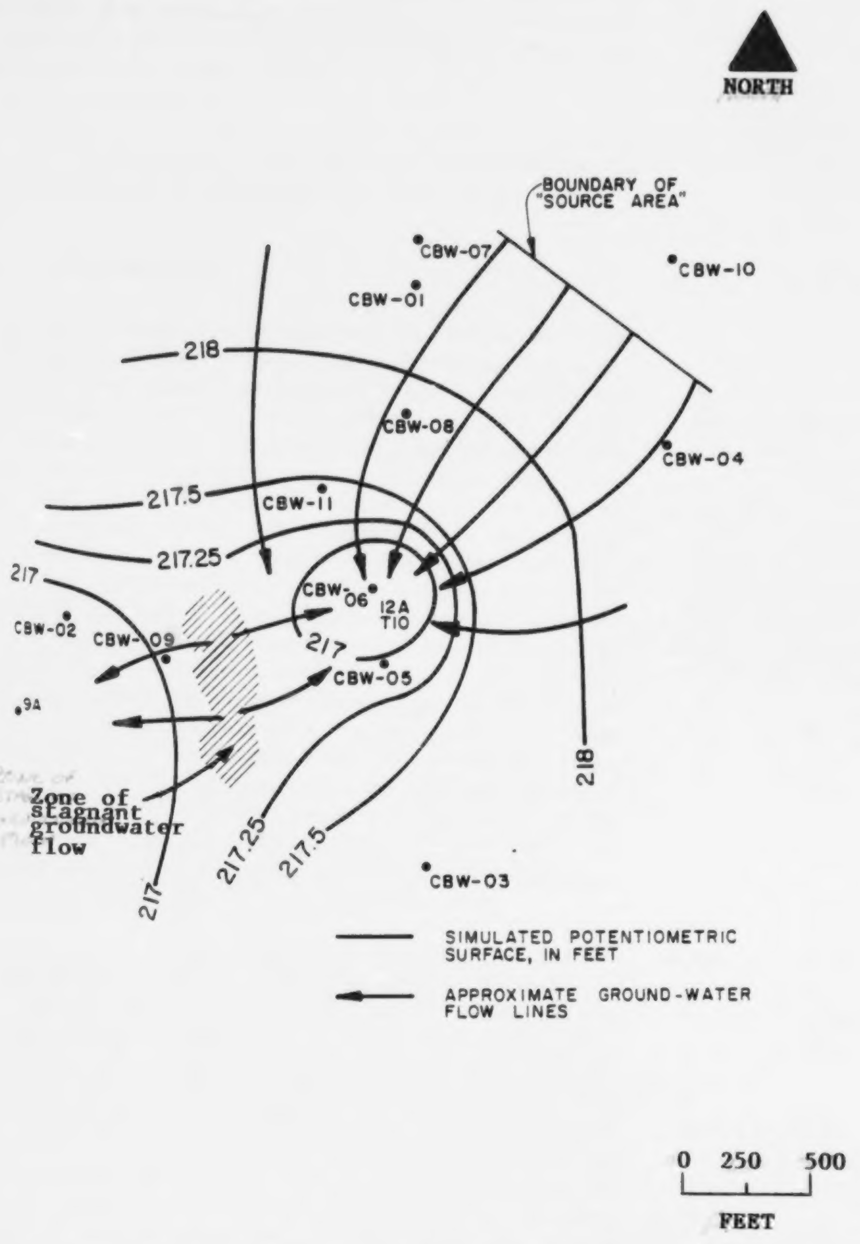

NORTH
BOUNDARY OF "SOURCE AREA"
CBW-07
CBW-10
CBW-01
218
CBW-08
CBW-04
217.5
CBW-11
217.25
217
CBW-06
12A
T10
CBW-02
CBW-09
217
CBW-05
9A
218
Zone of stagnant groundwater flow
217.25
217.5
217
CBW-03
SIMULATED POTENTIOMETRIC SURFACE, IN FEET
APPROXIMATE GROUND-WATER FLOW LINES
0 250 500
FEET

Figure 6. Model of Groundwater Flow Patterns - Well 12A = 2000 gpm, Well 9A = 3300 gpm, Well 11A* = 5000 gpm

* Well 11A not identified here because its location is beyond the area shown, however, its pumpage was part of model conditions.

Source: Black & Veatch 1983d

Figure 6: Model of Groundwater flow patterns - Well 12A = 2000GPM, Well 9A = 3300GPM, Well 11A 5000GPM

Figure 1). Verification of the contents and concentrations of chemicals in the deposit had not been received at the time of this writing; however, initial laboratory analyses indicated the presence of 1,1,2,2 tetrachloroethane, 1,2 trans-dichloroethylene, trichloroethylene and tetrachloroethylene, the same chlorinated compounds found in Well 12A water, in concentrations of greater than 2000 ppm (mg/l). Negotiations are presently under way with potentially liable parties. No further information is available on the history of disposal at this site.

DESCRIPTION OF CONTAMINATION

Tacoma's water supply was sampled in March 1976 as part of the National Organic Monitoring Survey. trichloroethylene was found, prompting local officials to begin investigating potential contaminant sources in the South Tacoma Channel area. In June 1981, an internal EPA memo comparing results from inorganic analysis of Well 9A (southwest of 12A) water indicated significant increases in chloride, hardness, iron and conductivity resulting from leachate migration from a landfill 0.5 mile (1.61 km) from the well. In July 1981, a routine inspection of an industrial/demolition landfill by the local health authorities found liquid wastes of unknown composition being disposed at the site. These wastes were traced to the American Surplus Sales Company. American Surplus had bought and sold paints, thinners, acids, greases, and other salvage items until the summer of 1981, when the firm was purchased by Floyd Equipment. Its employees disposed of the waste at the landfill. The proximity of Well 12A to American Surplus (see Figure 1) caused local officials to sample the well and significant levels of chlorinated organic solvents were found.

300.64(a)
preliminary
assessment

300.63(a)(2)
government
investigation

Because of the July 1981 sampling results, investigations were undertaken by the EPA, the State Department of Social and Health Services (OSHS), the Tacoma-Pierce County Health Department, and the City of Tacoma Department of Public Utilities. Chlorinated hydrocarbon contamination in Well 12A was confirmed in samples taken on July 21, August 21, August 27 and September 15, 1981. Compound concentration data for these and subsequent sampling periods are provided in Table 2. In addition, Well 9A 1000 ft (3,048 m) southwest of 12A) appeared to be contaminated at trace levels, but Wells 11A (4000 ft [1,219 m] southwest) and 2B (750 ft [230 m] west) were found to be clean.

300.63(a)(2)
government
investigation
300.65(b)(5)
sampling

300.65(a)(2)
contamination of
drinking water
supply

During the summer of 1982, Well 12A remained idle based on recommendations by the Center for Disease Control

TABLE 2. CONTAMINANT CONCENTRATIONS IN WELLS 2A, 2B, 6A, 9A, 11A, 12A and CBW10 (ppb)(ug/l)

Well	Date	Tetrachloro-ethylene	Trichloro-ethylene	Trans-dichloro ethylene	1,1,2,2-Tetra-chloroethane
2A	10/6/82	ND	<1.8	ND	ND
	10/27/82	ND	ND	ND	ND
	4/25/83	<1	0.9	<1	7.3
	5/26/83	<1	1.8	0.79	4.1
	6/14/83	13	2.3-2.6	0.4-4.1	11-13
	10/4/83	<0.1	0.4	<0.1	<0.1
2B	10/6/81	ND	<2.0	ND	ND
	10/27/82	ND	ND	ND	ND
	5/9/83	<1	1.9	<1	7.3
	6/14/83	5.2	3.4-23	1.3-2.0	5.2-18
	6/20/83	<1	4.8	3.9	15
	10/4/83	<0.1	0.6	<0.1	0.3
6A	5/12/83	<1	1.7	0.8	<1
	6/15/83	<0.1	3.5	<0.1	<1
	6/15/83	0.5	4.8	0.5	0.5
9A	10/4/82	ND	69	39	130
	10/27/82	ND	78	45	160
	5/17/83	<1	14	--	21
	5/23/83	<1	10	6.8	21
	5/26/83	<1	8.9	5.9	18
	5/31/83	<1	11	6.6	18
	6/6/83	<1	11	6.5	19
	6/9/83	<1	13-14	4.5-7.3	19-21
	6/20/83	0.3-25	11-19	5.3-25	25-28
	6/28/83	<1	14	5	16
	7/19/83	<1	16	3.4	18
	7/21/83	<1	13	4.5	13
	7/25/83	<1	12	3.7	14
	7/28/83	<1	10	3	11
	8/4/83	<1	13	3.6	11
	8/8/83	0.2	12	4.2	14
	8/11/83	0.2	8.2	5.0	13
	8/15/83	<1	7.6	2.5	9.6
	8/18/83	<1	7.9	4.0	12.0
	8/22/83	0.2-0.38	4.2-6.2	1.03-2.1	8.4-9.68
	8/25/83	0.2-0.28	2.86-6.3	0.75-1.3	9.05-9.4
	8/29/83	<0.1-.05	1.6-6.4	ND-0.7	7.0-8.5

(continued)

Source: Tacoma DPU 1984b

TABLE 2. (continued)

Well	Date	Tetrachloro-ethylene	Trichloro-ethylene	Trans-dichloro ethylene	1,1,2,2-Tetra-chloroethane
	9/1/83	<0.1	6.5	1.3	7.9
	9/6/83	<0.1	6.2	1.3	7.0
	9/8/83	<0.1-0.6	2.19-5.8	ND-1.4	6.6-8.39
	9/12/83	0.1	6.7	0.8	10.0
	9/15/83	0.1	6.8	1.0	10.0
	9/19/83	0.1	4.9	1.3	5.7
	9/22/83	0.1	4.9	1.3	5.6
	9/26/83	<0.1	5.4	1.4	6.2
	10/4/83	<0.1	4.8	1.1	6.4
	11/14/83	0.10	4.9	1.1	5.2
	12/27/83	0.68	2.84	2.76	2.52
	1/9/84	0.17	4.7	2.2	2.2
	2/21/84	0.22	4.56	2.18	3.12
	3/19/84	0.28	3.26	1.64	2.23
	4/15/84	0.26	3.15	2.42	2.38
	5/31/84	0.86	0.62	27.5	0.06
	5/31/84	0.3	3.6	0.4	2.3
	6/20/84	0.60	3.2	1.9	2.3
	7/31/84	0.42	4.9	4.3	2.2
	8/3/84	0.55	5.7	1.2	1.7
	8/16/84	0.06	2.3	<1.0	3.0
	8/30/84	0.27	2.46	<1.0	1.62
11A	10/7/82	ND	ND	<10	ND
	10/27/82	ND	ND	<10	ND
	3/14/83	<1	1.7	<1	<1
	6/07/83	<1	2.1	<1	<1
	6/15/83	<0.1-.5	1.6-3.6	<0.1-0.5	<1-0.5
12A	8/6/82	ND-<10	<10-13	<10	<10
	10/1/82	ND	38	21	24
	10/27/82	ND	25	11	16
	4/25/83	<1	4.7	1.8	2.8
	7/18/83	<0.1	0.33	0.63	0.4
	7/20/83	<0.1	2.4	1.7	1.6
	7/21/83	<1	7.3	1.8	1.5
	7/22/83	0.6	14.3	7.7	12.5
	7/23/83	0.7	24.5	8.3	19.3

(continued)

Source: Tacoma DPU 1984b

TABLE 2. (continued)

Well	Date	Tetrachloro-ethylene	Trichloro-ethylene	Trans-dichloro ethylene	1,1,2,2-Tetra-chloroethane
	7/28/83	<1	24.0	7.4	16.0
	8/4/83	<1	48.0	14.0	19.0
	8/8/83	0.5	68.0	18.0	47.0
	8/11/83	0.5	79.0	30.0	54.0
	8/15/83	1.6	69.0	18	61
	8/18/83(2)*	1.1-1.3	53.5-64.0	17.7-18	50-60.6
	8/22/83(2)	0.8-1.2	49.0-52.0	11-17.6	49-58.5
	8/25/83(2)	0.9-1.1	48.0-51.0	13-17	48-51
	8/29/83(2)	0.7-1.1	52-53	13.5-17.5	43-54
	9/1/83	0.8	49	14.7	41
	9/6/83 (2)*	0.4-1.0	46.3-48	13.0-13.8	39.0-43.7
	9/8/83	0.6	50	12.0	40.0
	9/12/83	0.8	43	9.5	34
	9/13/83	0.9	43.2	13.5	35.3
	9/15/83	0.9	45	10.0	34
	9/19/83(2)	0.6-1.0	41-43.1	9.1-26.5	33.0-33.9
	9/22/83	0.6	42.0	9.7	33.0
	9/26/83(2)	0.6-0.9	39-41	10.0-18	30.3-34
	10/4/83	0.7	39	9.5	32.0
	10/31/84	0.68	25.92	10.68	19.52
	11/28/84	0.3	18.0	4.7	16.0
	12/29/84	0.24	12.0	3.2	5.60
	1/23/84	0.18	5.7	3.99	4.94
	2/21/84	0.20	6.94	3.93	4.5
	3/19/84	0.16	4.43	2.13	1.92
	4/15/84	0.11	3.86	3.87	1.71
	5/31/84	3.21	1.49	3.78	0.01
	6/20/84	0.9	20.0	6.9	12.0
	7/31/84	1.9	43.1	8.2	24.7
	8/30/84	0.68	22.66	16.34	14.36
CBW-10	5/12/83	5.9	420	170	640
	7/14/83	6	513	170	760
	7/21/83	3	590	190	780
	7/28/83	4	480	160	800
	8/4/83	3	1800	220	1100
	8/8/83	<1	1866	304	2240
	8/11/83	<1	2111	228	3518
	8/15/83	58	2685	599	4532

(continued)

*(2) - Designates analysis of two samples
Source: Tacoma DPU 1984b

TABLE 2. (continued)

Well	Date	Tetrachloro-ethylene	Trichloro-ethylene	Trans-dichloro ethylene	1,1,2,2-Tetra-chloroethane
	8/18/83	62	3157	758	5617
	8/22/83(2)*	64-81	2137-3752	854-1229	4176-6749
	8/25/83(2)	62-98	2308-4243	1033-1273	4929-7946
	8/29/83(2)	35-98	891-5101	178-1079	4845-10307
	9/1/83	107	5310	972	10893
	9/6/83	2	6445	856	13714
	9/8/83 (2)	22-47	1135-6850	198-1042	6732-15343
	9/12/83	60	6396	763	17241
	9/15/83	79	7910	928	19807
	9/19/83	130	6118	665	17403
	9/22/83	130	7006	736	91637
	9/26/83	108	6431	774	20520
	10/4/83	150	6830	1050	19000
	10/31/84	100	15,000	5400	3000
	11/28/84	59.86	1368.48	1382.03	653.172
	12/27/84	37.99	697.78	922.84	835.36
	1/23/84	30.34	586.42	476.72	948.05
	2/21/84	14.39	411.30	219.14	572.30
	3/19/84	16.52	439.24	270.87	293.19
	4/15/84	11.42	354	113.48	131.31
	5/31/84	72.71	39	129.92	10.54
	6/20/84	73	511	190	400
	7/31/84	154	3250	430	21,000
	8/30/84	810.17	6138.54	2108	23,129.95

*(2) - Designates analysis of two samples
Source: Tacoma DPU 1984b

and the Tacoma-Pierce County Health Department. Frequent monitoring of Wells 12A and 9A (which was in service) during the summer of 1982 showed increasing contamination of Well 9A (with increased duration of pumping), and substantially lower concentrations in Well 12A from the previous year (see Table 2). This was the first indication that operation of Well 12A was critical to preventing further contamination of the well field.

As part of the remedial investigation implemented by the EPA, 11 groundwater monitoring wells were installed in the area (Figure 7). These wells are screened in the same major high permeability zone as 12A, with the exception of wells CBW-02, CBW-03, and CBS-05. Figure 8 illustrates the extent of contaminant plumes in the area as shown by samples taken from these monitoring wells.

300.61(c)
CERCLA financed
response

300.68(e)(2)(ii)
extent of substance migration

Initial remedial measures were completed by August 1983, and air stripping of groundwater at Well 12A began shortly thereafter. Monitoring data showed decreasing contamination in Well 9A, which also was operational and increasing concentrations in Well 12A, although at significantly less levels than previously found. Dramatic increases were noticed in monitoring Well CBW-10, located northeast of Well 12A between the well and the estimated source area. These analytical data support the geohydrologic model which holds that:

300.68(e)(1)
initial remedial
measures
300.68(e)(1)
(iii)
contaminated
drinking water

- Contamination is restricted to the highly permeable zone lying between 150 to 200 ft (46-61 m) MSL, the zone in which Wells 9A and 12A are screened.

- Units of lower permeability above and below the contaminated zone restrict contaminant movement to other aquifers despite a vertical hydraulic gradient.

- Groundwater flow northeast of Well 12A reverses direction, flowing toward Wells 9A and 12A (southwest) when they are in operation and away (northeast) from the wells under natural (non-pumping) conditions.

Monitoring data from wells screened in and out of the high permeability zone clearly show that wells screened in this unit are contaminated, but wells screened in other zones are contaminant-free. This, plus the boring records which indicate a more or less extensive lower permeability zone below 150 ft (46 m) MSL, supports the restriction of contamination to the 150 ft to 200 ft (46-61 m) MSL zone.

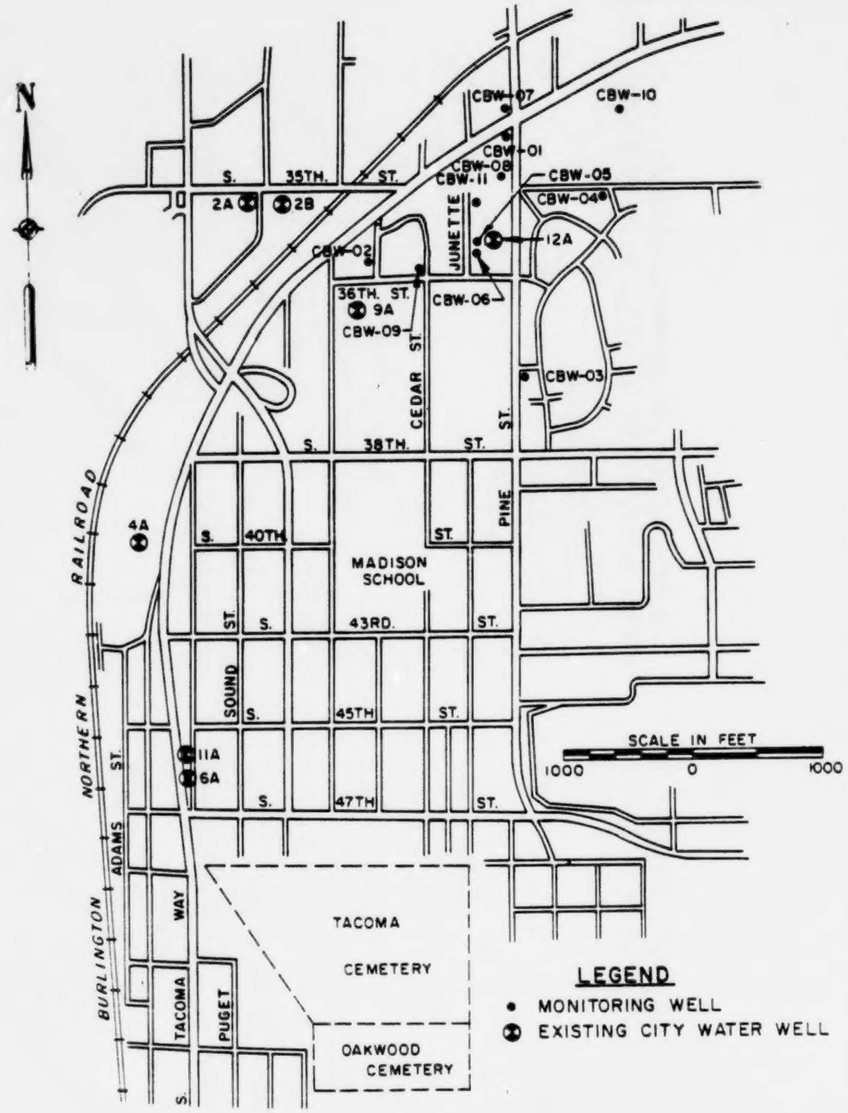
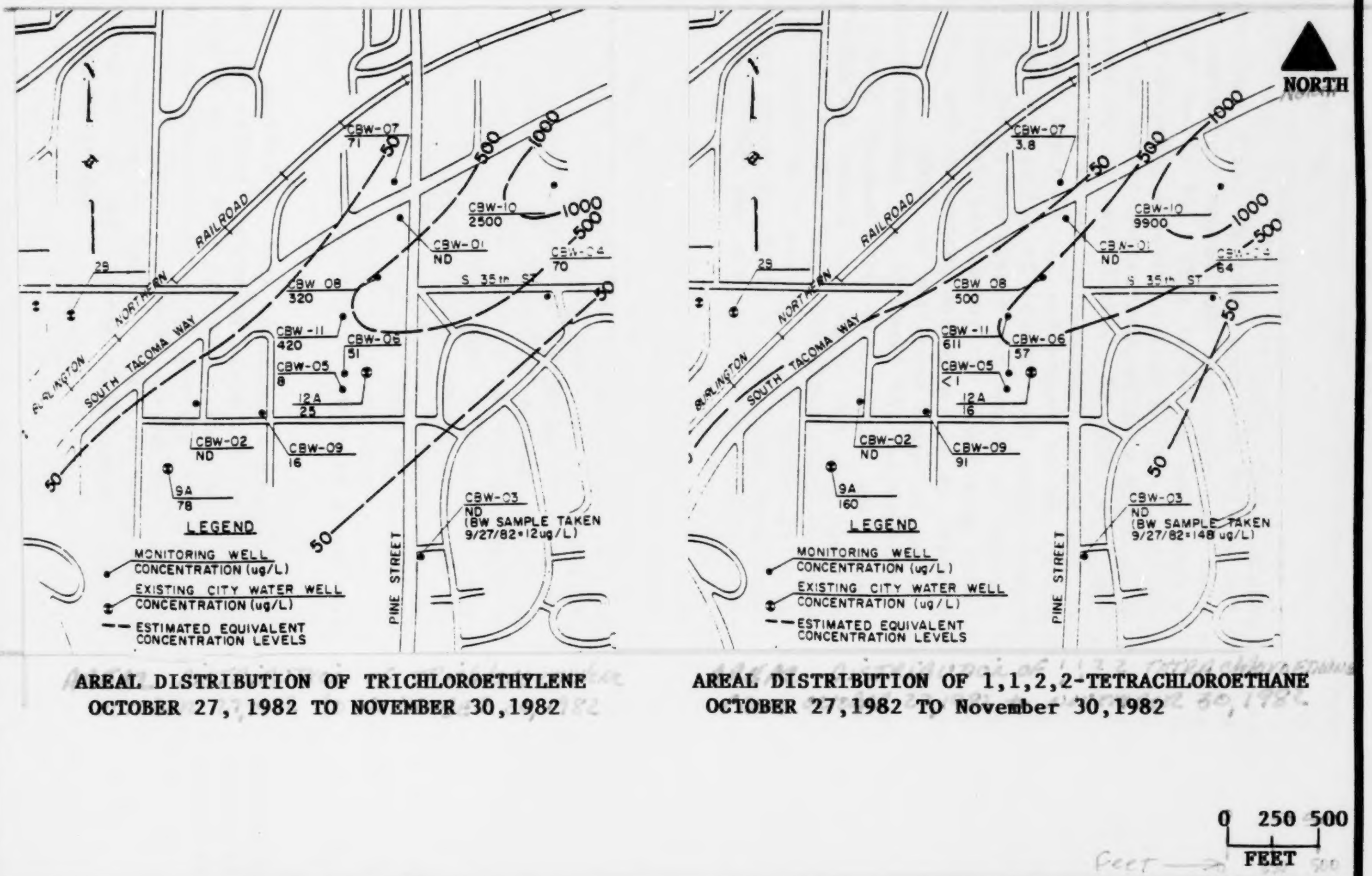


Figure 7. Monitoring Well Locations - Well 12A Area

Source: Black & Veatch 1983d

Figure 7: monitoring well locations ~~[illegible]~~ - well 12A Area.

Source:



AREAL DISTRIBUTION OF TRICHLOROETHYLENE
OCTOBER 27, 1982 TO NOVEMBER 30,1982

AREAL DISTRIBUTION OF 1,1,2,2-TETRACHLOROETHANE
OCTOBER 27,1982 TO November 30,1982

Figure 8. Map of Contaminant Plume - Well 12A Area

Source: Black & Veatch 1983d

Plume - well 12A Area

Table 3 presents total concentrations for target organics for Wells 9A, 12A, and CBW-10. The plots of these concentration levels over time (Figures 9 and 10) clearly show the effect of well field operations on contaminant flow. In 1981, when both Well 9A and Well 12A were operating, contaminant concentrations were high in 12A but low in 9A. This is easily explained: Well 12A was intercepting a major portion of the contaminant plume, preventing higher concentrations from reaching 9A and the remainder of the well field. In 1982, when Well 12A was shut down and 9A was operational, contaminant concentrations were lower in 12A and higher in 9A, 9A was drawing increased quantities of contaminated water from northeast of 12A. During the winter and spring of 1982-83, natural groundwater flow was moving the plume away from Wells 9A and 12A, and concentrations were low in these wells and Well CBW-10. When air stripping began in August, concentrations remained low for Well 9A, but increased for 12A and CBW-10 because the well field was again drawing contamination toward the wells, but the plume was being intercepted by Well 12A. The fluctuation of concentration levels could only have been possible if groundwater direction reversed. Table 4 summarizes these trends. One explanation for the dramatic pulse of contamination in CBW-10 (from 1500 ppb (ug/l) to 29,800 ppb (ug/l) in 2 months), and the lowered levels of contaminants in 12A is based on the alteration in the normal operations of the well field. Well 12A had not been operational except for short periods of time for 2 years prior to restart in August 1983. This reduced the cone of depression and, presumably, the limit of groundwater flow direction reversal northeast of the wells. Natural flow diluted and moved the major plume further to the northeast than if Well 12A had been operating. Therefore, the large concentration increase in Well CBW-10 documents the major plume being drawn back toward 12A, a condition similar to that existing in the summer of 1981 before contamination was discovered. Again, this phenomenon can only be explained by the existence of a reversing groundwater flow direction.

The analytical data confirm the existence of a contaminant plume extending from the area northeast of Well CBW-10 to the Well 12A area. The major area of high contaminant concentration is located northeast of Well CBW-10 but is drawn southwest during well field operations. Vertically, the area of contamination appears restricted to the high permeability zone between 150 to 200 ft (46-61 m) MSL.

300.68(e)(2)(ii)
extent of substance migration

TABLE 3. TOTAL ORGANICS

COMBINED CONCENTRATION OF TETRACHLOROETHYLENE, TRANS-DICHLOROETHYLENE, TRICHLOROETHYLENE, 1,1,2,2-TETRACHLOROETHANE

Well 9A		Well 12A		Well CBW-10	
Date	Concentration (ppb)	Date	Concentration (ppb)	Date	Concentration (ppb)
10/6/82	238	7/21/81	354.7		
10/27/82	283	8/6/82	<33		
5/17/83	35	10/1/82	83	5/12/83	1235.9
5/23/83	37.8	10/27/82	52	7/14/83	1449
5/26/83	32.8	4/25/83	9.3	7/21/83	1563
5/31/83	35.8	7/18/83	1.36	7/28/83	1444
6/6/83	36.5	7/20/83	5.7	8/4/83	3123
6/9/83	36.5-42.3	7/21/83	10.6	8/8/83	4410
6/20/83	41.6-97	7/22/83	34.5	8/11/83	5857
6/28/83	35	7/23/83	52.8	8/15/83	7874
7/19/83	37.4	7/28/83	47.4	8/18/83	9194
7/21/83	30.5	8/4/83	81	8/22/83	7231-11811
7/25/83	29.7	8/8/83	133.5	8/25/83	8332-13560
7/28/83	24	8/11/83	163.5	8/29/83	5949-16585
8/4/83	27.6	8/15/83	149.6	9/1/83	17282
8/8/83	30.2	8/18/83	130.3-143.9	9/6/83	21017
8/11/83	26.4	8/22/83	109.8-128.8	9/8/83	8087-23282
8/15/83	19.7	8/25/83	109.1-120	9/12/83	24460
8/18/83	23.9	8/29/83	109.2-125.6	9/15/83	28724
8/22/83	13.8-18.3	9/1/83	105.5	9/19/83	24216
8/25/83	12.9-17.5	9/6/83	98.7-106.5	9/22/83	27509
8/29/83	8.6-15.6	9/8/83	102.6	9/26/83	27833
9/1/83	15.7	9/12/83	87.3	10/4/83	27030
9/6/83	14.5	9/13/83	92.9		
9/8/83	8.8-15.7	9/15/83	89.9		
9/12/83	17.6	9/19/83	83.7-104.5		
9/15/83	17.9	9/22/83	85.3		
9/19/83	12	9/26/83	79.9-93.9		
9/22/83	11.9	10/4/83	81.2		
9/26/83	13.1				
10/4/83	12.3				

Source: Data compiled using sampling analyses results from various documents from the City of Tacoma, Department of Utilities dated 10/19/82 through 10/1983.

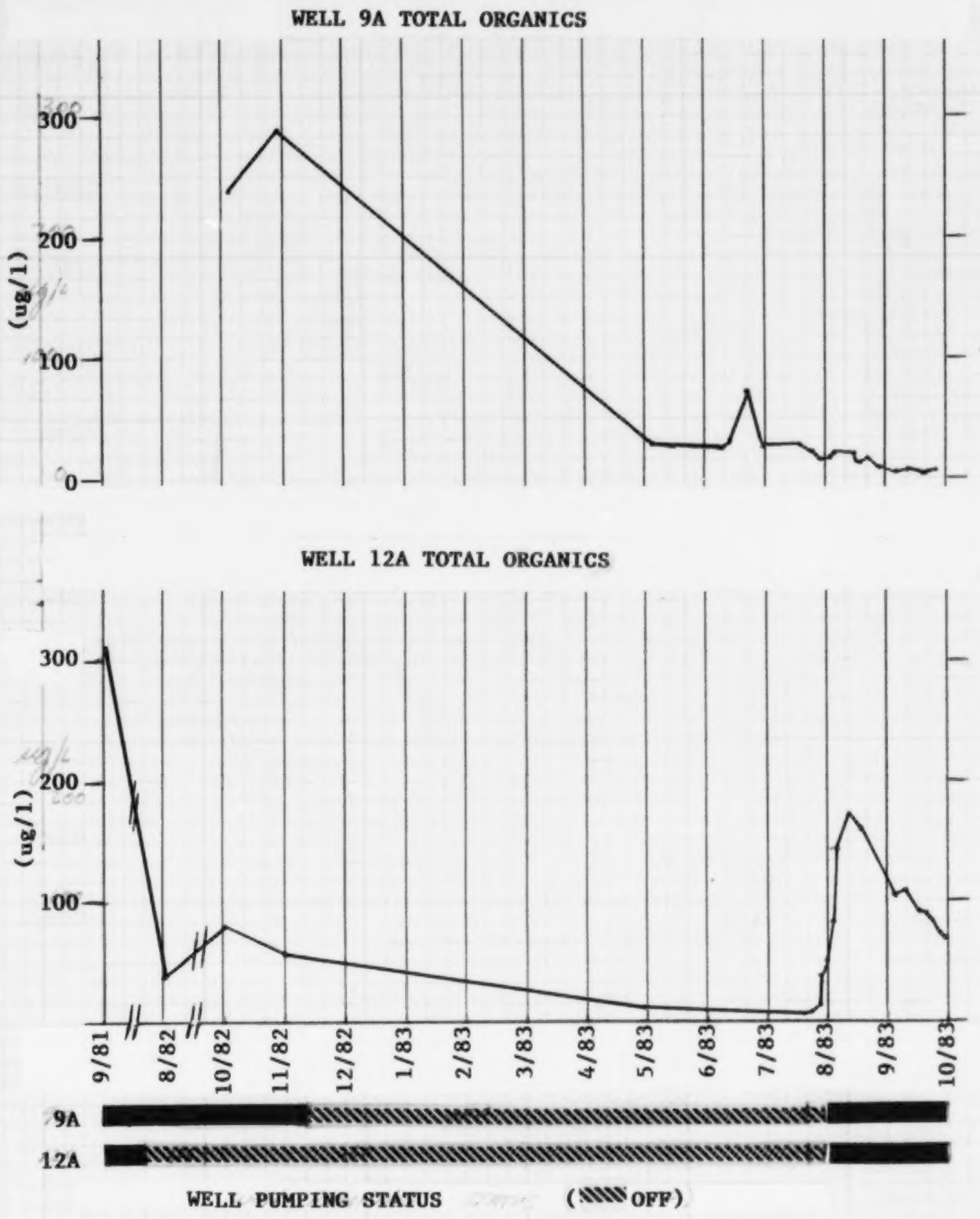


Figure 9. Total Organic Concentration Trends - Wells 9A* and 12A - Compared to Well Pumping Status

* Well 9A in operation but not being used as water supply.

Source: Compiled by JRB Associates using data from the Tacoma DPU.

Figure 9: Total organic concentration trends - wells 9A and 12A - compared to well pumping status

Source:

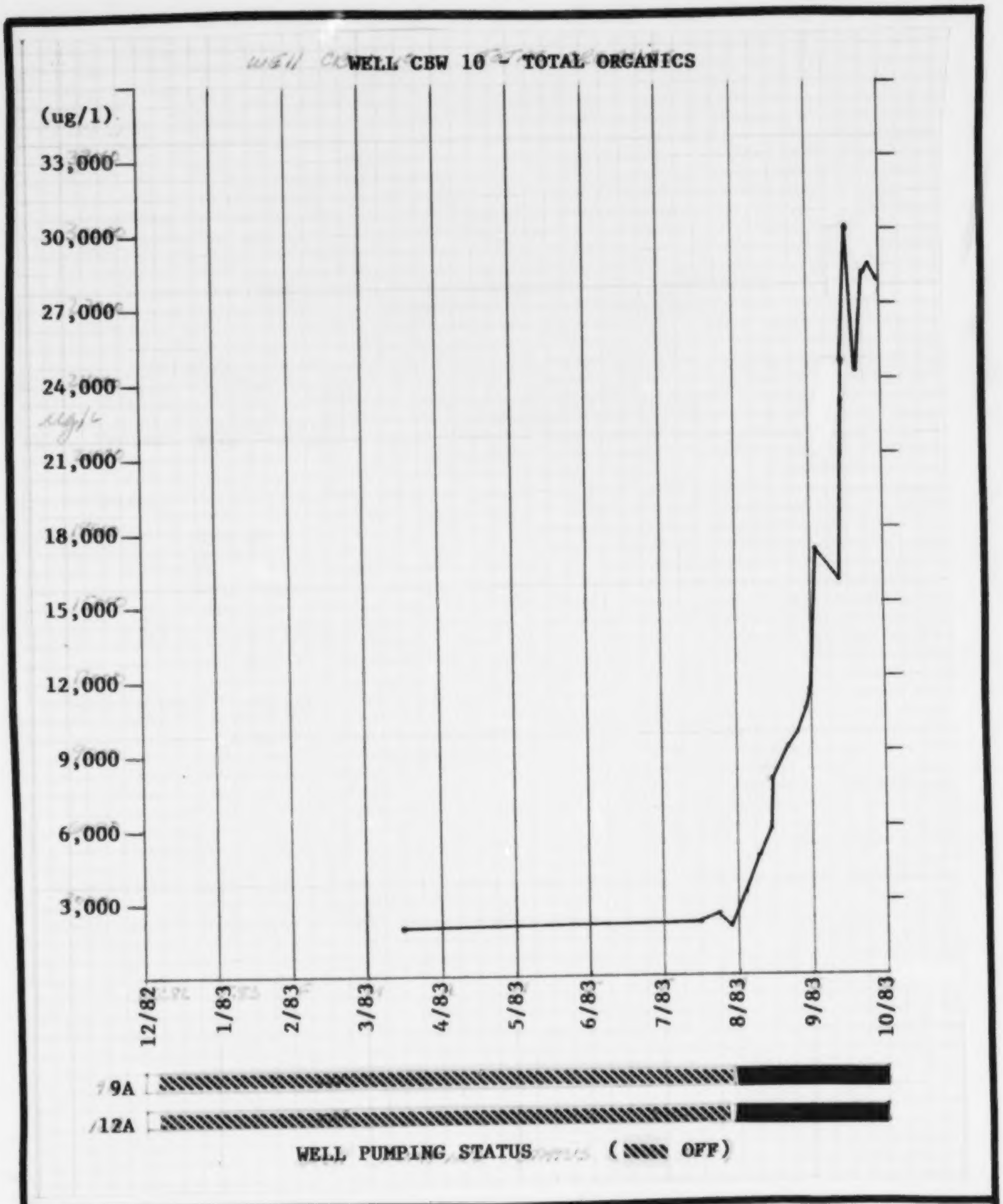


Figure 10. Total Organic Concentration Trends - Well CBW 10 - Compared to Well Pumping Status

Source: Compiled by JRB Associates using data from the Tacoma DPU.

Figure 10: Total organic co[illegible] trends - well CBW-10
compared with well pu[illegible] status

TABLE 4. CONTAMINANT CONCENTRATION TRENDS IN WELLS 12A, 9A, AND CBW-10

Time Period	Well Status	Relative Contaminant Concentration in Wells 12A	 9A	 CBW-10	
9/81	12A On 9A On Well Field On		High	Low	—[1]
9/82 - 7/83	12A Off 9A On	Low	High	—[1]	
7/83 - 10/83	12A On[2] 9A On	Increasing from Low to High	Decreasing	Increasing Dramatically (1500 ppb - 30,000 ppb)	

[1] CBW-10 not installed until late 1982 - no chemical quality data available.

[2] Well 12A on with air stripping system operating.

PLANNING THE SITE RESPONSE

The sequence of events leading to discovery of the problem at Well 12A began with the routine sampling and testing of Tacoma well water by the National Organic Monitoring Survey in March 1976. Survey results were published by the U.S. EPA Office of Drinking Water in 1978 and indicated traces of trichloroethylene in Tacoma well water. Shortly thereafter, an investigation was begun by the Washington State Department of Ecology and the Tacoma-Pierce County Health Department to identify the possible sources of contamination. One nearby industrial concern, American Surplus Company, bought and sold chemicals, solvents, and paint thinners. Discovery of several thousand containers of stored chemicals at this site in July of 1981 prompted the sampling of a supply well, Tacoma Well 12A, which is located less than two blocks away.

During sampling efforts in July through September 1981, synthetic chlorinated organic compounds were discovered and confirmed in the water from Well 12A. A remedial investigation by the FIT was authorized on April 20, 1982 by EPA Region X. The concentration gradient found by the FIT extended beyond the original geographic boundaries of the field investigation. The work of the FIT was hence expanded in April 1983 by amendment to the State Superfund Contract to search for sources in a larger geographical area. At present it is believed that the primary source has been found, although confirmation of this is pending further investigation.

300.63(a)(2)
government
investigation

An Initial Remedial Measure (IRM) was authorized on March 18, 1983, to treat the contaminated water of Well 12A. A Cooperative Agreement between the State and EPA allowing funding for the project was signed on June 22, 1982.

Criteria for the full-scale design were developed from bench-scale testing by late April 1983. Construction of the Well 12A treatment facility began in May 1983.

Enforcement actions began by notifying nine potentially responsible parties in May 1982. Their responses gave no indication as to the location of the source of contamination. Since the EPA did not have sufficient information to link a specific party to the pollution, they proceeded with a remedial investigation. On April 21, 1983, investigators from EPA Region X and the Washington Department of Ecology inspected the facilities at 3011 South Fife Street in Tacoma. Analysis of sludge from a deposit at this site showed high concentrations of

1,1,2,2 tetrachloroethane (23,000 ppb) (ug/l) present with various other organic chemicals in lower concentrations. Further sampling produced similar results and enforcement action is currently under way against the owners of the property.

Selection of Response Technologies

Response activities and studies to select remedial technologies for Well 12A, although carried out with some urgency, were in keeping with the EPA guidance, i.e., the National Contingency Plan available at the time. The importance of quickly addressing the problem centered on three items:

1. Remedial investigations undertaken by EPA and local authorities concluded that additional supply wells would become contaminated unless Well 12A remained in operation and acted as a barrier restricting plume movement.

   300.66(c)(2)(iii) assessing migration potential

2. Without water provided by the well field, severe water shortages (by almost 30 percent) would result, which could only be offset by mandatory rationing.

   300.68(e)(2)(iv) environmental effects and welfare concerns

3. Risks associated with the contamination were unacceptable. The Center for Disease Control concluded in April 1983 that a definite health threat existed if water contamination at levels like that in Well 12A groundwater were used for drinking.

   300.64(a)(1) evaluation of hazard
   300.65(a)(2) threat to drinking water

Remedial investigations initially failed to identify the source of contaminants but sufficiently characterized the hydrogeologic situation so that initial remedial measures could be evaluated. Of the alternatives investigated, only air stripping and carbon adsorption were considered viable responses. Data from bench scale and pilot plant studies, along with computer modeling identified air stripping as the more economical and efficient alternative. System construction began in May 1983, and air stripping operations commenced in August 1983.

300.68(e)(2)(i) extent of threat to health, welfare, or environment
300.67(a)(1) substantial cost savings

Remedial alternatives were first evaluated in July 1982 when the EPA tasked its zone contractor for the Well 12A area to conduct a study to collect data supporting a feasibility study for remedial action, to characterize the hydrogeologic system in the area, and to support the design of a selected remedial measure. By January 1983,

300.68(f) remedial investigation
300.69(g) development of alternatives

sufficient data had been collected to meet study objectives, but the major source of contamination had not been identified. As part of the study, a preliminary list was developed of possible initial remedial measures (IRM), and the important selection factors were identified (Table 5). Final cleanup measures, however, could not be developed until the source(s) of contamination was found.

300.68(h)
initial
screening of
alternatives

In January 1983, a meeting was held between EPA and its regional contractors. At this meeting, EPA outlined specific tasks to be completed, including:

- Calculate the minimum Well 12A pumping rate needed to effectively block contaminant migration
- Calculate the maximum discharge rate to the city sewers
- Prepare a concept design and cost for reducing 12A discharge
- Estimate the plume configuration under various 12A and 9A pumping scenarios.

As part of the presentation made at that January 1983 meeting, the regional contractors summarized the information gathered to date on the Well 12A situation as well as the technical considerations affecting IRM selection:

- The magnitude of contamination in supply wells is a function of the pumping history of Wells 12A, 11A, and 9A.
- The magnitude of contamination in Well 12A may increase with increased pumpage.

300.68(e)(3)
(iii)
extent of
present or
repeated
migration

- Contaminant transport is primarily in the horizontal direction.
- Pumping of Wells 9A and 12A changes the direction of the steady state gradient.
- Continuous pumping of Well 12A will act as a barrier to some degree to migration of the contaminant plume toward wells south and west of 12A.
- Tacoma may require the use of Well 12A and possibly 9A July through September 1983 unless conservation measures are implemented.

TABLE 5. REMEDIAL ACTION ALTERNATIVES IDENTIFICATION, COMMENCEMENT BAY, WELL 12A

	Adverse Environmental Effects	Effectiveness	Accepted Engineering Practice	Complete Construction	Pilot/ Bench	Capital Cost $	O&M $	$/1,000 gal.
Abandoned Well 12A and site new well	Doesn't cleanup 12A area. 9A contaminant conc. will increase, thus 9A would need to be abandoned & resited. Contaminant plume may move toward other wells in Hood St. system.	Would provide potable supply, but not address cleanup.			None	N/A until Remedial Investigation	N/A	N/A
Contaminant Plume Control	May require barrier and/or recharge wells.	Would still require treatment. May accelerate contaminant movement to Well 12A to reduce time which treatment process must be on line.	RMA and other projects		Pilot/ Bench for treatment			
Operations Control	No treatment of 12A discharge. Control concentrations by varying 12A discharge.	Wouldn't reduce conc. of contaminants from 12A, but would control conc. leaving Hood St. Reservoir.	None identified.	N/A	N/A			
Ozone	Heavy Power requirements.	No info available on these constituents.				2-3 times GAC	2-3 times GAC	2-3 times GAC
PAC (Powdered Activated Carbon)	Needs settling basin. Hood St. Reservoir would need frequent cleaning.	Substantially less than GAC.				25% of GAC	25% of GAC	25% of GAC
Resin (Ambersorb)	Poor regeneration capability.	Equivalent or greater than GAC.				6-10 times GAC	6-10 times GAC	6-10 times GAC
No Action	12A and surrounding area remain contaminated. Potential for other wells to become contaminated.	Not effective		N/A	N/A	0.00	0.00	0.00

Source: USEPA 1982

(continued)

TABLE 5. (continued)

	Adverse Environmental Effects	Effectiveness	Accepted Engineering Practice	Complete Construction	Pilot/ Bench	Capital Cost $	O&M $	$/1,000 gal.
Diffused Air Aeration	May increase localized corrosivity of water.	Aeration may remove majority of contaminant but may require use of GAC or resin to accomplish final polishing.	Done on smaller scale.	4-6 month design, 12 mo. const.	Pilot	$440,000	$11,000/mo.	0.105
Forced-Draft Aeration	May increase localized corrosivity of water	May require use of GAC or Resin to accomplish final polishing.	Done on smaller scale.	1 month design, 4 mo. const.	Pilot	$180,000	$1,500/mo.	0.023
Granulated Activated Carbon (Permanent)	Regeneration of GAC	Exclusive use would be effective treatment.	Usually have primary treatment prior to use of GAC. GAC normally final step.	6-8 month design. 12 mo. const.	Bench & Pilot	$1,320,000	$195,000/ Regeneration	0.097+ Regeneration
Granulated Activated Carbon (Temporary)	Regeneration of GAC.	Same as GAC (permanent)	Same as GAC (permanent).	4 mo. design and const.	None	$260,000 for 1st month.	$20,000/mo. + 195,000/ Regeneration	
Granulated Activated Carbon (with aeration pretreatment)	Regeneration of GAC.	Optimal over using aeration or GAC by themselves	Done on smaller scale.	5 month to 20 months depending on temporary or permanent GAC.	Pilot	Less than permanent GAC	Less than permanent GAC	Less than permanent GAC

Source: USEPA 1982

- The IRM may be designed as the final phase of a long-term treatment program.

A draft feasibility study report was submitted to EPA by its regional contractor in February 1983. The study was developed to assess temporary remedial measures to prevent the spread of groundwater contaminants to Tacoma's supply wells and to supply the city with water sufficient to meet its summer water demand for several years. The measures were expected to be temporary because ongoing city, State, and EPA investigations were expected to quickly identify the source.

300.65(b)(7)
barriers to
deter spread of
release

Options available for use in addressing the Well 12A situation and evaluated during the feasibility study included:

- The "no action" alternative
- Abandonment of Well 12A
- Plume containment through source control
- Aquifer replacement
- Pumping and treatment of contaminated water.

The "no action" alternative was evaluated by determining the need for remedial measures using historical water use data and risk factors for expected levels of contaminants. Table 6 lists water supply data from the City of Tacoma Water Department, indicating the amount of water supplied by Well 12A. This table indicates the need to keep Well 12A in operation.

300.68(e)(3)(ii)
extent of
present or
expected
migration

Table 7 lists projections of contaminant concentrations in the groundwater and water system under several scenarios.

Table 8 includes calculations using results from Table 7, which completed the endangerment assessment. This assessment ruled out the "no action" alternative. The following general assumptions were necessary to complete the assessment:

300.64(a)(1)
evaluation of
hazard
300.68(e)(2)(i)
extent of threat
to health,
welfare, or
environment

- Analytical data and projections are accurate.

- Significant No Adverse Response Levels (SNARLs) and Water Quality Criteria Document (WQCD) risk levels are accurate.

TABLE 6. SUMMARY OF TACOMA WATER SUPPLY DATA SHOWING NEED FOR WELL 12A SUPPLY (1972-1982)

	Maximum Demand (Mg)		
	30 day	4 day	1 day
Maximum Demand, mgd.	108	121	128
Demand on wellfield	36	49	55
Surplus/Shortfall - All wells	+9	-4	-10
Surplus/Shortfall - Minus 12A	+3	-10	-16
Surplus/Shortfall - Minus 12A, 9A	-1	-14	-20

Maximum wellfield capacity	45 mgd
Capacity without well 12A	39 mgd
Capacity without well 12A, 9A	35 mgd

Well 9A delivers directly to distribution

Well 12A delivers directly to reservoir

All other wells are directed to one of two reservoirs

Dilution of Well 12A in Hood Street Reservoir is 1:6.

Source: USEPA 1983a

TABLE 7. PROJECTIONS OF CONTAMINANT CONCENTRATION IN CITY OF TACOMA WATER

Scenario[1]	Estimated Total Organic Concentration-12A	Estimated Concentration in Hood St. Reservoir
Small source, Well 12A pumped	1,000 ug/1 (12A)	166 ug/1
Large source, Well 12A pumped	15,000 ug/1 (12A)	2500 ug/1
Small source, Well 12A not pumped	---	2000 ug/1
Large source, Well 12A not pumped	---	1000 ug/1

[1] Limiting Assumptions

A. Source identification in 5 years, followed by immediate source control.

B. Plume boundary not known, therefore small and large sources used as limits.

C. Well 12A pumping will prevent contaminants from entering any other wells.

D. Contaminant concentrations would only be diluted by other system wells and no removal or degradation of contaminants would take place.

Source: USEPA 1983a

TABLE 8. ENDANGERMENT ASSESSMENT CALCULATIONS

I. CASE 1: No treatment, flow 3500 gal/min, concentrations:

- o 1,1,2,2 tetrachloroethane = 350 ppb
- o 1,2-trans-dichloroethylene = 200 ppb
- o trichloroethylene = 450 ppb

A. 1,1,2,2 tetrachloroethane

1. 350 ppb/90 days exposure =
87.5 ppb/360 days exposure =
14.6 ppb/360 days with 6-fold dilution[1]

2. 10^{-5} risk = 1.7 ppb

$$\frac{14.6}{X} = \frac{1.7}{10^{-5}} \quad (X = \text{risk})$$

$$X = \frac{14.6}{1.7} \times 10^{-5}$$

$$X = 9 \times 10^{-5} \quad 1 \times 10^{-4} \text{ risk}$$

B. 1,2-trans-dichloroethylene

1. 200 ppb/90 days exposure =
50 ppb/360 days exposure =
8.3 ppb/360 days with 6-fold dilution

2. 10^{-5} risk = .33 ppb

$$\frac{8.3}{X} = \frac{.33}{10^{-5}}$$

$$X = \frac{8.3}{.33} \times 10^{-5}$$

$$X = 25.15 \times 10^{-5} \quad 2.5 \times 10^{-4} \text{ risk}$$

---

[1] 6-fold dilution factored in because of mixing of Well 12A water in Hood St. Reservoir before water enters distribution system.

Source: USEPA 1983a

(continued)

TABLE 8. (continued)

C. Trichloroethylene

1. 450 ppb/90 days exposure =
112.5 ppb/360 days exposure =
18.8 ppb/360 days with 6-fold dilution.

2. 10^{-5} risk = 45 ppb (SNARL) 27 (WQCD)

$$\frac{18.8}{X} = \frac{45}{10^{-5}} \qquad \frac{18.8}{X} = \frac{27}{10^{-5}}$$

$$X = \frac{18.8}{45} \times 10^{-5} \qquad X = \frac{18.8}{27} \times 10^{-5}$$

$$X = .42 \times 10^{-5} \quad 4.2 \times 10^{-6} \qquad X = .71 \times 10^{-5} \quad 7 \times 10^{-6}$$

II. CASE 2: No treatment, flow 3500 gal/min, concentrations

- 1,1,2,2 tetrachloroethane = 5000 ppb
- 1,2-trans-dichloroethylene = 3000 ppb
- trichloroethylene = 7000 ppb

A. 1,1,2,2 tetrachloroethane

1. 5000 ppb/90 days exposure =
1250 ppb/360 days exposure =
208.3 ppb/360 days with 6-fold dilution

2. 10^{-5} risk = 1.7 ppb

$$\frac{208.3}{X} = \frac{1.7}{10^{-5}}$$

$$X = \frac{208.3}{1.7} \times 10^{-5}$$

$$X = 122.5 \times 10^{-5} \quad 1.2 \times 10^{-3}$$

Source: USEPA 1983a

(continued)

TABLE 8. (continued)

B. 1,2-trans-dichloroethylene

1. 3000 ppb/90 days exposure =
   750 ppb/360 days exposure =
   125 ppb/360 days with 6-fold dilution

2. 10^{-5} risk = .33 ppb

$$\frac{125}{X} = \frac{.33}{10^{-5}}$$

$$X = \frac{125}{.33} \times 10^{-5}$$

$$X - 378.8 X 10^{-5} \quad 3.8 \times 10^{-3}$$

C. Trichloroethylene

1. 7000 ppb/90 days exposure =
   1750 ppb/360 days exposure =
   291.7 ppb/360 days with 6-fold dilution

2. 10^{-5} risk = 45 ppb (SNARL)   27 (WQCD)

$$\frac{291.7}{X} = \frac{45}{10^{-5}} \qquad \frac{291.7}{X} = \frac{27}{10^{-5}}$$

$$X = \frac{291.7}{45} \times 10^{-5} \qquad X = \frac{291.7}{27} \times 10^{-5}$$

$$X = 6.4 \times 10^{-5} \qquad X = 10.8 \times 10^{-5} = 1.1 \times 10^{-4}$$

Source: USEPA 1983a

- Well 12A water will be used for drinking 90 days/year and will continue for a lifetime for each exposed individual (USEPA 1983b).

- It is appropriate to average 90-day-exposure over the entire year. (Exposure to 40 ppb/90 days is equivalent to 10 ppb/360 days exposure.)

- Well 12A water undergoes complete, 6-fold dilution at reservoir.

- Total risk is equal to the sum of risks associated with each individual contaminant.

- Maximum concentration of pollutants in raw water will not exceed the air stripping cleansing capacity.

- Risk factor of 1,2-trans-dichloroethylene is assumed to be equivalent to risk factor of 1,1-dichloroethylene.

- Predicted incremental cancer excess rates (i.e., one extra incidence of cancer per population) associated with lifetime exposure ppb (ug/l), via drinking water, are as follows:

Population	10^4	10^5	10^6	Source
1,1,2,2-tetrachloroethane (ppb)	17	1.7	.17	WQCD
1,2-transdichloroethylene (ppb)	3.3	.33	.033	WQCD
trichloroethylene (ppb)	450	45	4.5	SNARL
	270	27	2.7	WQCD

- Risks for 1,2-transdichloroethylene are assumed to be equivalent to those for 1,1-dichloroethylene. (This assumption was necessary because no risk factor was available for the "trans" isomer.)

Total risks, calculated from Table 8 results (total risk being defined as risk compound A + risk compound B + risk compound C, etc.), indicate that under case 1 at least one extra death by cancer per 10,000 people drinking water over a lifetime could be expected, and under case 2, risks exceed 1 extra death by cancer per 1000 people. These figures show that the "no action" alternative was unacceptable.

300.68(e)(2)(i)(A)
population at risk

Abandonment of Well 12A was not determined to be a viable option. Hydrogeological studies pointed out that shutting down Well 12A would not alleviate the problem; contaminants would migrate to other supply wells. Risks similar to those of adding untreated Well 12A water to the distribution system were associated with drinking water from the wells once they became contaminated.

300.65(b)(4)
controlling source
of release

Containment of the plume through source control was not a viable system for two reasons:

300.70(b)(1)(iii)
(2)
plume containment

1. Contaminant source had yet to be identified, so the actions required to implement this alternative could not be specified nor evaluated against other options.
2. The residual contamination in the aquifer system would continue to enter the supply system, for the short term at least, with unacceptable risks.

Aquifer replacement was evaluated and found not to be feasible because no other water sources of the size needed could be developed in time to supply water during the peak season.

300.65(b)(2)
alternative water
supplies

Pumping and treatment of Well 12A was evaluated and found to be the only feasible solution which would keep Well 12A operational (preventing the further spreading of contamination), and thus reduce the risks posed to the population drinking Tacoma water. Conventional treatment processes such as coagulation, sedimentation, precipitative softening, filtration, and chlorination were not applicable to Well 12A because they are ineffective in treating volatile organic compounds. Oxygenation was evaluated but removed from consideration because of the limited success demonstrated in pilot scale studies. Aeration and adsorption remained as the only technologies capable of addressing the situation since the well could not be replaced or shut down, and that the risks of drinking untreated water were unacceptable.

300.70(d)(2)
provision of
alternative water
supply
300.70(b)(1)(iii)
(C)
groundwater
pumping
300.70(b)(2)(ii)
(A)(1)
conventional
wastewater
treatment
300.70(b)(2)(ii)
(C)(1)
air stripping
300.70(b)(2)(ii)
(C)(2)
carbon adsorption

There are two aeration technologies that effectively strip VOCs (volatile organic compounds) from water:

- Diffused air strippers make use of diffusers or porous plates submerged in basins to bubble air up through water. Untreated water enters the top of the basins, while treated water is removed at the bottom. Air and VOCs leave at the top. Basin shape, rate of diffusion, and bubble size affect transfer efficiency.

- Tower type strippers use towers packed with material of high void volumes and high surface area to break water cascading down through the tower into thin films or drops. Air forced upward through the packing material strips off VOCs which exit from the top of the tower. Induced draft towers draw air up through the tower using fans located on top of the towers, while forced draft towers force air upward using blowers positioned at the bottom of the towers. In both tower types, water is pumped to the top of towers and cascades under gravity down through the towers.

Air stripping had been identified as a viable Well 12A treatment technology as early as June 1982, when the City of Tacoma Water Division requested Montgomery Consulting Engineers to develop a preliminary design for air stripping towers to remove 90 percent of the trichloroethylene at Well 12A. By July 1982, the preliminary design was completed and submitted to the Water Division. The theoretical design was based on removing VOCs with Henry's Law Constants of 90, similar to trichloroethylene. (The greater the Henry's Law Constant the more volatile the compound, and the easier the compound is to strip from groundwater). The report recommended a system with one stripping tower 12 ft (3.66 m) in diameter and 19 ft (5.79 m) high to remove 90 percent of the VOCs with a Henry's Law constant of 90.

Although showing the suitability of the technology, the study was not immediately applicable to Well 12A. The study was theoretical, and bench scale or pilot plant studies had not been conducted. In addition, a greatly enlarged system would be required to treat Well 12A contaminants like 1,1,2,2-tetrachloroethylene, with a Henry's Law constant of around 15, much harder to remove than trichloroethylene.

Two types of carbon adsorption mechanisms were evaluated for use at Well 12A:

- Adsorption by synthetic resin, an experimental process that showed promise for removing low molecular weight halogenated compounds. (This system was removed from consideration after the manufacturer announced that the resin would not be available for commercial use.)

- Adsorption by granular activated carbon (GAC), using vessels packed with GAC operating in series so each adsorption vessel could be operated until

> the GAC had reached capacity. GAC is more effective when used to treat "unsaturated" organics (e.g., ethylenes). Saturated compounds like 1,1,2,2-tetrachloroethane are less readily adsorbed by GAC.

Carbon isotherm tests were conducted to determine the efficiency of stripping VOCs from Well 12A water using GAC. Tests were run using simulated raw well water and simulated partially stripped water. (Testing using simulated partially stripped water would indicate the cost and effectiveness of using GAC to "polish" water after air stripping had partially removed VOCs.) Concentrations of 872 ppb (ug/l) for raw and 376 ppb (ug/l) for partially stripped water were used in tests. Two scenarios were tested: treating 3,500 gallons/minute (13,250 l/min) and treating only 2,000 gallons/minute (7,570 l/min).

The purpose of the isotherm test was to determine the amount of organics adsorbed per gram of carbon. Isotherms are shown as Figures 11 and 12. These results were evaluated for scale-up to batch and continuous processes. Twenty-nine pounds of carbon/1,000 gallons of water (13 kg_C/355 l H_2O) were required for batch systems, but only 24 pounds (10 kg) were required for continuous operation. Table 9 gives the estimated costs for treating raw or partially treated water using either GAC system.

The pilot plant study of air stripping VOCs was carried out at the U.S. Bureau of Mines Research Facility in Albany, Oregon. The purpose of the study was to determine if the compounds of concern at Well 12A could be stripped without problems, and to determine the mass transfer coefficient. These coefficients indicate the rate at which a given quantity of a VOC is removed from the liquid (and transferred to the gaseous state). The rate of liquid and air flow in the system impact mass transfer coefficients; the mass transfer increases as liquid and gas flow rates increased.

Two pilot plant tests were run, using simulated Well 12A water and air at ambient temperatures and at 6°C (low temperatures decrease Henry's Law constants and make compounds more difficult to remove). In addition, two different total concentrations were used for the simulated Well 12A water. Table 10 lists pilot study test parameters. In running the tests, incoming air was saturated with water vapor to decrease the evaporation rate of the water through the column and facilitate calculation of mass transfer coefficients.

Simulated Well 12A Water

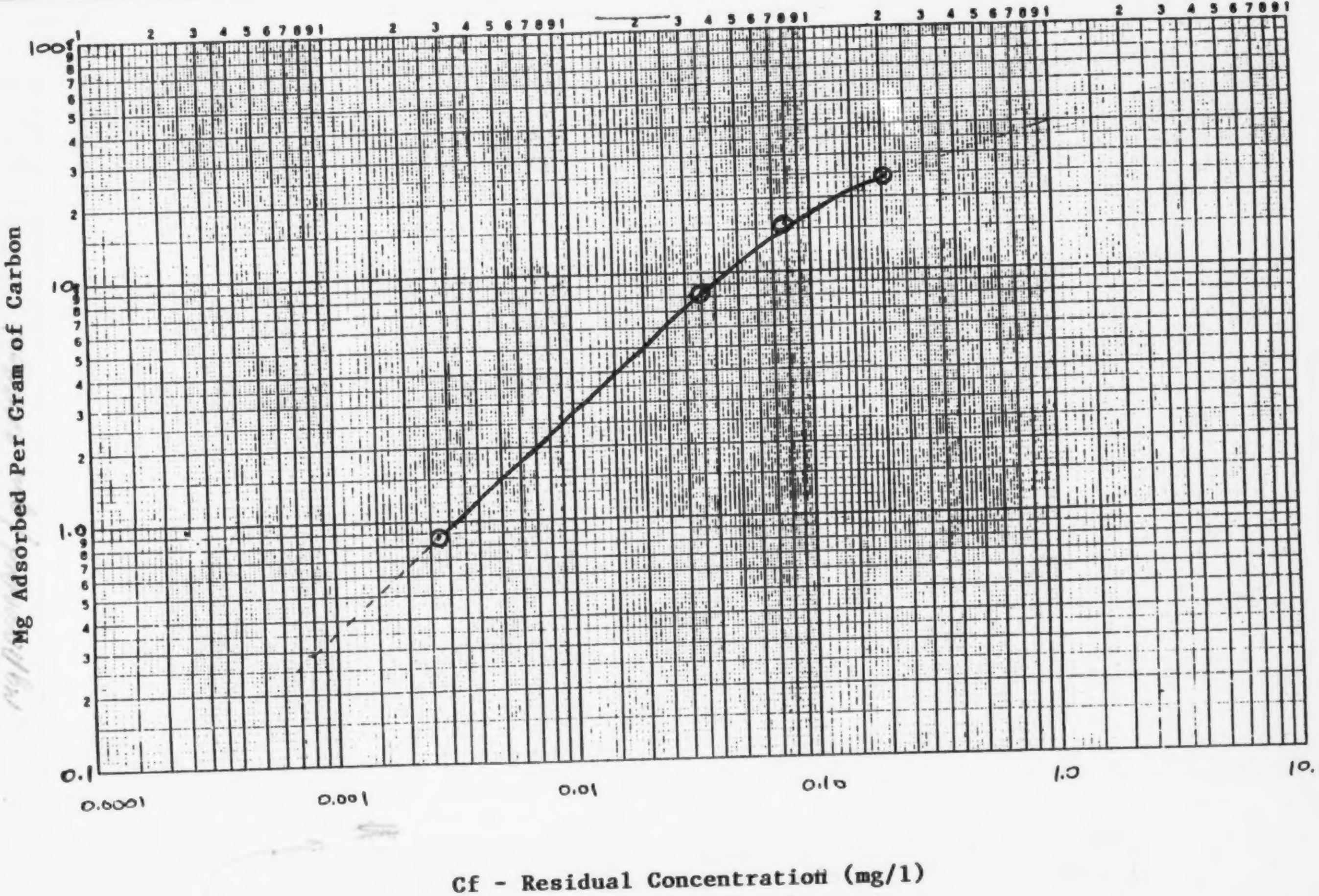


Figure 11. Isotherm for Carbon Adsorption on Simulated Well 12A Water (No Treatment)

Source: CH2M Hill 1983h

Adsorption on Simulated Well 12A Water (No Treatment)

Partially Treated water.

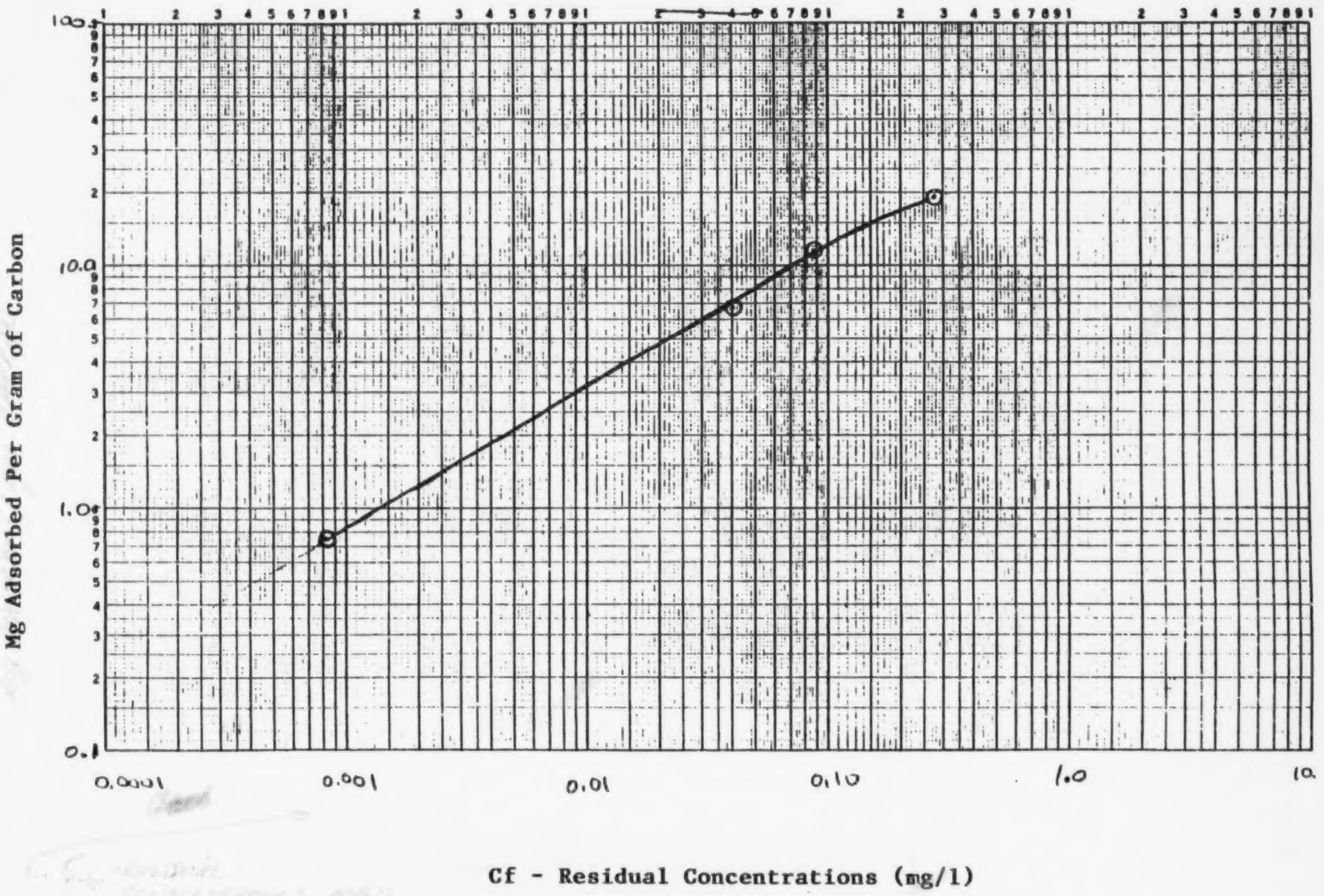


Figure 12. Isotherm for Carbon Adsorption on Partially Treated Well 12A Water

Source: CH2M Hill 1983h

TABLE 9. PROJECTED CARBON REQUIREMENTS AND COSTS (TACOMA WELL 12A USING GAC)

	Daily Carbon Requirement (LBS)	Daily Carbon Cost[1] ($)	Three-Month Carbon Cost ($) ($ x 1,000)
BATCH			
2000 gpm - Raw (29 lb/1000 gal)	83,520	83,520	8,000
2000 gpm - Partial Treatment	NA	NA	
3500 gpm - Raw	146,160	146,160	14,000
3500 gpm - Partial Treatment	NA	NA	
CONTINUOUS			
2000 gpm - Raw (24 lb/1000 gal)	691	691	64
2000 gpm - Partial Treatment	518	518	48
3500 pgm - Raw	1,210	1,210	113
3500 gpm - Partial Treatment	907	907	84

[1] Based on GAC cost of $1/lb.

Source: CH2M Hill 1983h

TABLE 10. PILOT TEST PARAMETERS

	Test 1	Test 2
Temperature (Air)	Ambient	6°C
Total VOC Concentration	710 ppb	1500 ppb
1,1,2,2-tetrachloroethane	398 ppb (56%)	840 ppb (56%)
trans-1,2-dichloroethylene	135 ppb (19%)	285 ppb (19%)
trichloroethylene	170 ppb (24%)	360 ppb (24%)
tetrachloroethylene	7 ppb (1%)	15 ppb (1%)

Source: CH2M Hill 1983h

Figure 13 illustrates the apparatus used to run the pilot plant tests. Air for the stripping column was first run through a bed of GAC to remove any organic contaminants. Runs for each test were made using three liquid rates and three or four gas rates.

Table 11 contains the results of the pilot tests. Removal of VOCs (as percentages) increased with decreasing liquid to gas ratios in all runs. As expected, the percent removal of VOCs varied with the Henry's Law constants, i.e., 1,1,2,2-tetrachloroethane with the lowest constant also had the lowest percent removal.

Coefficients for mass transfer were calculated based on the pilot test results and compared with results calculated from empirical models. One model generated mass transfer coefficients greater than those found during the test and was not used further. Another model predicted greater mass transfer values at lower liquid/gas rates and lower values at higher liquid/gas rates than those from the pilot test. However, because of the closer agreement, this model was selected to predict mass transfer coefficients for a full-scale system.

System scale-up and design required consideration of numerous parameters to optimize the air stripping systems. Well flow rate, total contaminant concentrations, compounds present, and desired percent removal had to be considered during system design. The compound

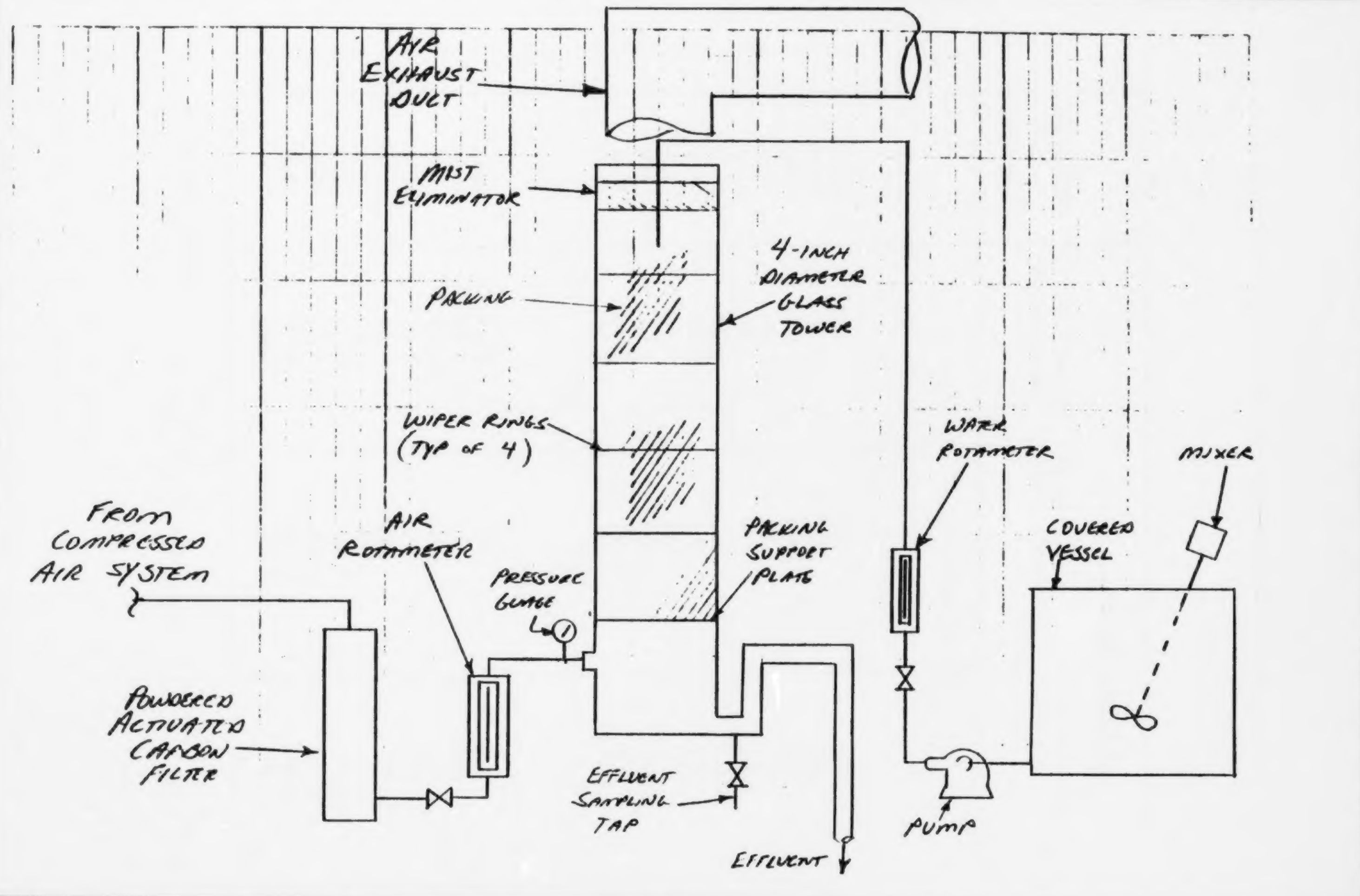


Figure 13. Pilot-Plant Test Apparatus - Well 12A Air Stripping System

Source: CH2M Hill 1983h

TEST APPARATUS - WELL 12A AIR STRIPPING SYSTEM.

SOURCE:

TABLE 11. PILOT PLANT STUDY TEST RESULTS

		Percent Removal				
	Liquid/Gas Ratio (vol/vol)	1,1,2,2-Tetrachloroethane	Trans-1,2-dichloroethylene	Tetrachloroethylene	Trichloroethylene	Total
Test 1 Run No.						
1	.0013	100	100	100	100	100.0
2	.0020	99.5	100	100	100	99.7
8	.0075	92.9	100	100	100	95.7
6	.0095	82.3	100	100	100	89.2
7	.0116	88.6	100	100	100	93.0
5	.0157	56.2	100	100	100	73.1
4	.0239	45.2	100	100	100	66.4
3	.036	98.9	100	100	100	99.3
11	.039	33.6	100	97.1	95.3	57.8
10	.0438	26.0	95.0	100	94	52.4
9	.0634	19.1	94.2	94.4	91.9	47.9
Test 2 Run No.						
1	.0022	99.8	100	100	100	100
2	.0038	99.5	100	100	100	97.3
3	.005	81.9	100	100	100	89.1
10	.0077	71.5	100	100	100	83.0
6	.0101	66.4	100	98.7	100	80.0
5	.0167	36.2	97.4	97.4	96.8	60.9
4	.0218	18.2	96.6	96.2	95.4	49.7
9	.0365	17.9	93.9	93.6	92.4	48.3
8	.0421	10.6	90.5	89.0	88.5	42.9
7	.0657	10.4	87.2	87.2	84.3	40.7

Source: CH2M Hill 1983h

1,1,2,2-tetrachloroethane was identified as the contaminant of concern because of its low Henry's Law coefficient. In addition, packing size and shape had to be considered (the smaller the packing, the greater the mass transfer efficiency, and the greater the pressure drop).

In running the scale-up model, the following parameters were used:

- One-inch (2.5-cm) saddle-packing material was used because of the high mass transfer efficiency and acceptable pressure drop.
- Liquid to gas rates were low to effect removal of the target compound.
- Twelve-foot (3.6-m) diameter towers were selected because they were capable of providing low liquid loadings and because special permits were not required to transfer the towers.

Calculations for the scale-up are included as Table 12. These calculations indicated that five towers, each with 20.8 feet (6.3 m) of packing, would remove 88 percent of 1,1,2,2-tetrachloroethane from 3500 gpm (13,250 l/min) of Well 12A water. Table 13 shows the decrease in calculated removal efficiency if less than five towers are operating.

Cost-effectiveness curves were generated for the described air stripping system. Figure 14 depicts these curves for 3500 gpm (13,250 l/min) system, showing that the five-tower system, is more effective at removing the target compound than a four-tower system, with an associated minimal cost increase.

Other conclusions drawn that affected system design included:

- The effect on air quality would be significant (Table 14 summarizes system emissions). 300.68(i)(2)(E) adverse effects
- Noise levels would be below State of Washington noise standards.
- The system would have an inherent salvage value.

TABLE 12. SCALE-UP DESIGN CALCULATIONS

ASSUMPTIONS: Influent = 350 ppb 1,1,2,2-Tetrachloroethane = X in
Effluent = 42 ppb 1,1,2,2-Tetrachloroethane = X out
Flow = 3500 gallons/minute
Mass Transfer Coefficient for 1,1,2,2-Tetrachloroethane = $K_L a$ = 41 lb - moles/ft^3-hr-mole fraction
Packing = No. 1 Superintalox (Norton)

Stripping Rate, R
R = H G/L where
H = Henry's Law Constant
L = Liquid Rate (lb-moles/ft^2-hr)
G = Gas Rate (lb-moles/ft^2-hr)
H = 6 ATM/Mole Fraction

METHOD: Determine H, G, L

Step 1: Determine L

$$L = \text{Flow} \quad \frac{X\ in}{X\ out} \quad \text{Conversion Factor} \quad \text{Time} \quad \frac{1}{\text{Tower Surface Area}}$$

$$L = \frac{3500\ gal}{min} \quad \frac{8.34\ lb}{gal} \quad \frac{lb\text{-}mole}{18\ lb} \quad \frac{60\ min}{hr} \quad \frac{1^{1}}{565\ ft^2}$$

L = 172 lb-mole/ft^2-hr

Step 2: Determine G for L = 172 Lb-mole/ft^2-hr and manufacturers data to yield minimum head loss (use manufacturers curves)

G = 40 lb-moles/ft^2-hr

Step 3: Determine R (H)

$$R = (H)\ (G/L) = (g)\ (40/172) = 1.40$$

Step 4: Determine number of transfer units (for R, X_{in}, X_{out})

$$NTU = {}^{R}/R\text{-}1\ Ln\ {}^{X}in/X_{out}\ (R-1) + {}^{1}/R$$
$$= {}^{1.40}/1.40\text{-}1\ LN\ \ 8.33\ (1.40 - 1) + {}^{1}/1.40$$
$$= 3.95\ ft$$

(continued)

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[1] 5 Towers at 113 ft^2 (12 ft diameter) = 565 ft^2

Source: CH2M Hill 1983h

TABLE 12. (continued)

Step 5: Calculate Height of Packing Depth
Packing Depth = z = (NTU) x Height of Transfer (HTU)

$$\text{HTU} = \frac{L}{K_L a} \quad \text{(only at low concentrations)}$$

$\text{HTU} = 172/41 = 4.20$ ft

$z = (3.95)\ (4.20)$

$z = 16.6$ feet

Step 6: Add safety factor of 25%

$z = 16.6 \times 1.25 = 20.8$ ft 21 ft.

Source: CH2M Hill 1983h

TABLE 13. DECREASE IN STRIPPING EFFICIENCY
(INFLUENT 350 PPB (UG/L) OF 1,1,2,2-TETRACHLOROETHANE)

Number Of Towers	Effluent Percent Removal	Concentration
5	88	42
4	81	67
3	69	109
2	48	182
1	20	280

Source: CH2M Hill 1983h

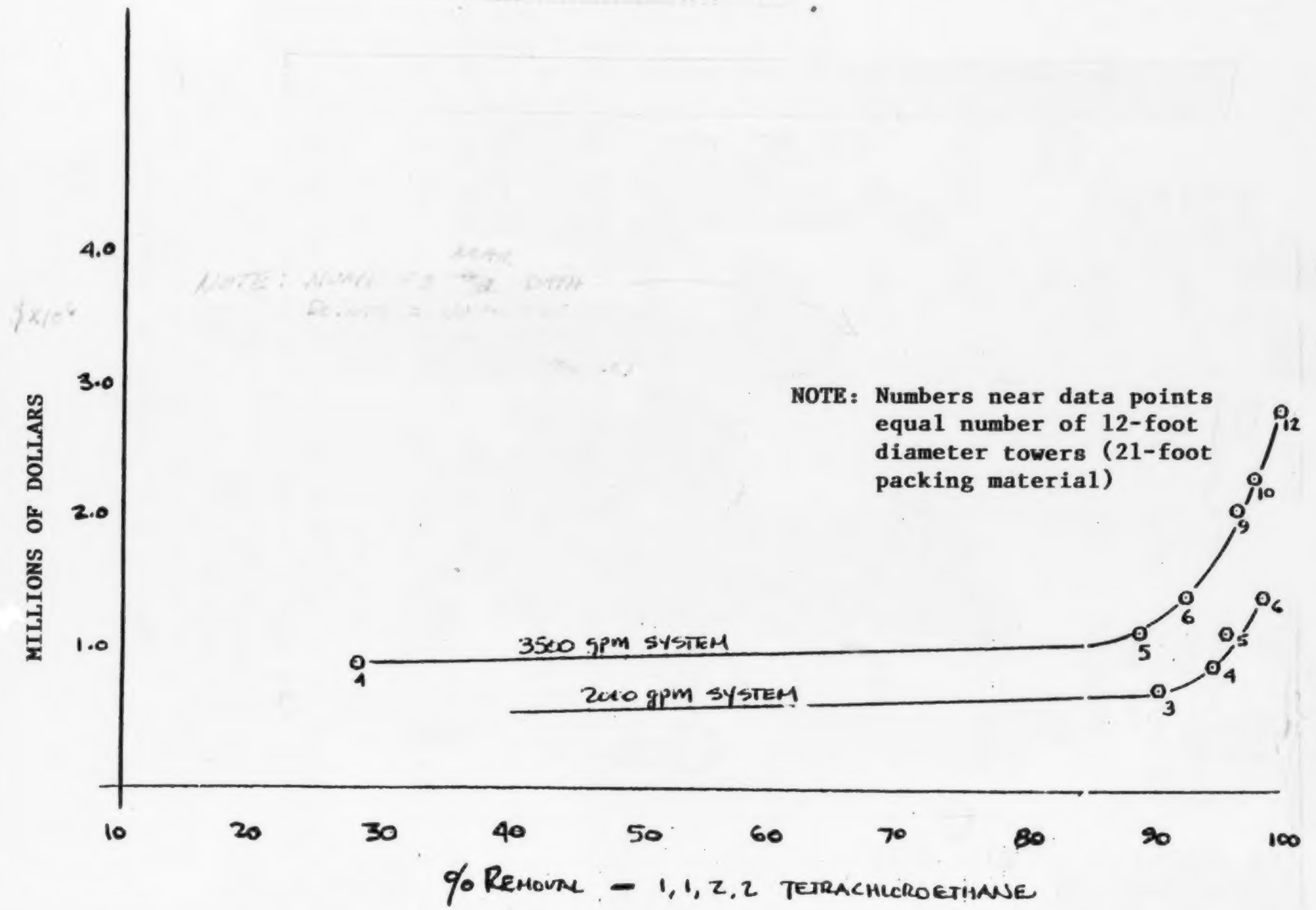


Figure 14. Cost Versus Removal Efficiency (1,1,2,2- Tetrachloroethane)

Source: USEPA 1983a

TABLE 14. CALCULATED STRIPPING TOWER EMISSIONS (3500 GPM, 88% REMOVAL OF 1,1,2,2-TETRACHLOROETHANE, 99% REMOVAL OF ALL OTHER VOCS)

Component	Continuous Stack Emissions At Stack (ppm in Air) (mg/1)	Maximum 8-hr Ground Level Concentration (ppm in Air) (mg/1)	Current OSHA 8-hr Standard (ppm in Air) (mg/1)
1,1,2,2-tetrachloroethane	.14	.008	5
1,2-transdichloroethylene	.16	.009	200
trichloroethylene	.26	.14	100
tetrachloroethylene	.004	.0002	100
	.564	.1572	405

Source: CH2M Hill 1983h

Further study of the GAC system was discontinued at this point because of the high cost of GAC as compared with air stripping. Other factors that played a part in the decision were:

- Operation and maintenance costs were estimated to be double those for air stripping (continuous carbon contactors at 3500 gpm (13,250 l/min treating raw water).

300.68(i)(2)(B) distribution of costs over time

- Handling equipment (removal and disposal or regeneration of spent carbon) were additional costs not associated with air stripping systems.
- GAC systems were determined to be less flexible than air stripping systems should contaminant concentrations be higher (e.g., higher concentrations would require more frequent GAC replacement).

Based on the air stripping pilot plant studies and the cost-effectiveness analyses, the following recommendations were made:

- The treatment system be installed to treat 3500 gpm (13,250 l/min) of water contaminated at 1000 ppb (ug/l) total VOC

- The system be capable of removing 90 percent of 1,1,2,2-tetrachloroethane and 99 percent of all other VOCs

- Five 12-foot (3.6 m) diameter towers packed with 21 feet (6.4 m) of 1-inch (2.5 cm) super intalox saddles be installed.

The record of decision approving the allocation of Superfund monies to implement the system design was signed on March 16, 1983.

Extent of Site Response

Laboratory analyses of treated water from Well 12A indicated a removal efficiency of 98 percent for volatile organic compounds stripped during the 1983 operational period. 1,1,2,2-tetrachloroethane, the most difficult contaminant to remove, generally was removed at efficiencies above 95 percent, and all other contaminants were removed at rates approaching 100 percent.

Goals for the Remedial Action as stated in the Record of Decision (March 16, 1983) were to produce a "timely remedial action to protect public health and the environment, in a feasible and cost-effective remedy. . . [which would be] a necessary component of any final remedy that will effectively and reliably mitigate and minimize damage to, and provide adequate protection of public health, welfare and the environment."

More specific goals for the treatment system were to "provide treatment capacity for a flow adequate to allow Well 12A to act as a barrier to further contamination of other wells in the well field." Secondarily, the treatment system was designed to treat the water so that it could be used as a source of drinking water for the peak demand months. Thus, the aquifer was to be partially cleansed by the operation of the treatment system.

Effluent quality standards set on the system were for less than 15.5 pounds per year (7.03 kg/yr) and were based on guidelines established by the County Health Department for a risk level at one case per 1,000,000 people for VOCs.

Design and Execution of Site Response

Remedial actions implemented at Tacoma Well 12A consisted of constructing an air stripping system capable of reducing levels of VOCs to concentrations suitable for discharge to the city's drinking water system. The objectives of this initial remedial measure were to:

- Permit operation of the well to block the spread of contaminants
- Partially clean up the aquifer
- Supply drinking water to the system when treated effluents were within applicable water quality standards.

The system was considered to be a temporary measure while further studies were under way to identify the contaminant source and to design and implement a permanent solution. Because of this, a life of five pumping seasons was used during the design process, although the actual term of operations remained dependent on the outcome of further studies and the implementation of a permanent cleanup plan.

The system, as installed at Well 12A, is summarized in Table 15. Construction began in May 1983 and was completed on July 18, 1983. The system was brought on-line in August 1983 and treated water first flowed into the water system on August 4, 1983.

The Well 12A design process began in January 1983 (6 months before system start-up), as a joint effort among the EPA, the Tacoma/Pierce County Health Department, the Tacoma Water Division, the Washington State Department of Social and Health Services (DSHS), and the Washington State Department of Ecology. EPA's regional contractor for the area was responsible for conducting the design and construction management activities. Once operational, the system was to be turned over to the Water Division.

TABLE 15. PROCESS DESIGN SUMMARY

Number of towers	5
Inside diameter	12 feet (3.6 m)
Packing depth	21 feet (6.4 m)
Total flow to be treated	3500 gpm (13,250 l/min)
Flow per tower	700 gpm (2,650 l/m)
Air flow rate per tower	29,000 SCFM
Liquid to gas ratio	
- (LB mole/LB mole)	4.3
- (vol/vol)	0.0161
Headloss through packing	.25 inches H_2O/ft
Discharge	to Hood St. Reservoir or Commencement Bay

A project design group was established by the regional contractor to design and implement the Well 12A remedial measure. Specific subgroups were responsible for the following areas:

- Overall project coordination
- Process studies
- Permits
- Design
- Construction management.

Weekly meetings of a project management team which consisted of representatives from both contractor and government agencies, reviewed project status, identified critical path items, and discussed problems.

The initial target date to begin the Well 12A treatment system (July 1) required that each group conduct simultaneous activities, modified as needed because of progress made by other groups (e.g., refined final project design would affect preparation of bid packages). At first the bench-scale tests on air stripping and carbon adsorption were the critical path items (see section on Selection of Response Technologies). By February 8, 1983, the bench tests had been completed, and because of the high costs associated with carbon adsorption ($2/1000 treated gallons) ($2/3,785 treated liters) as compared to air stripping ($0.25/1000 treated gallons) ($0.25/3,785 treated liters), plus the greater effectiveness of air stripping, this technology was determined to be the best available alternative.

Concurrent with the regional contractor's efforts, the EPA Office of Drinking Water, Technical Support Division in Cincinnati ran an air stripping computer model calibrated against laboratory results, which eventually supported the results of the bench scale test. (However, the EPA model selected a system with 13 10-ft (3.05 m) diameter towers with 21 feet (6.4 m) of packing and 190,000 SCFM air flow, which, during the continuing design studies did not prove to be the most cost-effective design.)

Because of the fast track, manufacturers and vendors were being contacted in early February by members of the design group. Soil borings were being made to support foundation studies, system flow sheets and computer specifications files were being developed, and major components were being designed. These activities were aimed at identifying engineering specifications, costs, and lead time.

The construction management group had already opened discussions with vendors and suppliers to identify schedule problems, interest in the project, and feasibility of meeting the July 1 start-up date. The overall schedule and preliminary system cost estimates developed by this group indicated that the July 1 date could be met within project costs.

Finally, the permits group had already made contact with both the Puget Sound Air Pollution Control Agency and the Department of Ecology (DOE) to inform them of the project plan and to determine what permits would be required. Because of the VOCs discharged to the air, an air permit would be required but permit approval was likely given the small quantities of material involved. An NPDES permit would also be required if the system discharged effluent to Commencement Bay. Initial indications from DOE were that drinking water quality standards were being considered as permit conditions.

The result of all this activity was that, by early February, the bench-scale tests had identified air stripping as the most likely alternative, process design activities were well under way, contacts had been made with vendors, a project completion schedule had been drawn up, and the required permits had been identified.

Significant progress had been made by the middle of February:

- Modeling had begun to determine emissions from an air stripping system.

- Contacts with the Tacoma-Pierce County Health Department and State Department of Ecology indicated that an NPDES permit would be difficult to obtain in time; however, an alternative involving discharge to the storm sewer and ultimately to the city waterway would only require modification of the existing water quality standard.

- Tacoma noise standards had been examined, noise suppression measures were probably necessary, and changes to the design were being incorporated.

- EIS procedures had been examined and a decision reached that an EIS would not be required because of the State's emergency action provision (WAC 197-10-180).

- Several conceptual designs had been developed and costed. At this point, each tower was 30 ft (9.1 m) high with an integral sump, packing retainer, influent distributors, a demister system, and access ports. Connections would be to influent and effluent headers, with monitoring access built in. Air was to be provided by a 40 HP motor blower with noise suppression. Fittings were to be provided so that each tower could be isolated from the others for maintenance.

- Vendors indicated that authorizations and approvals had to be obtained by early March to meet the July 1 start date.

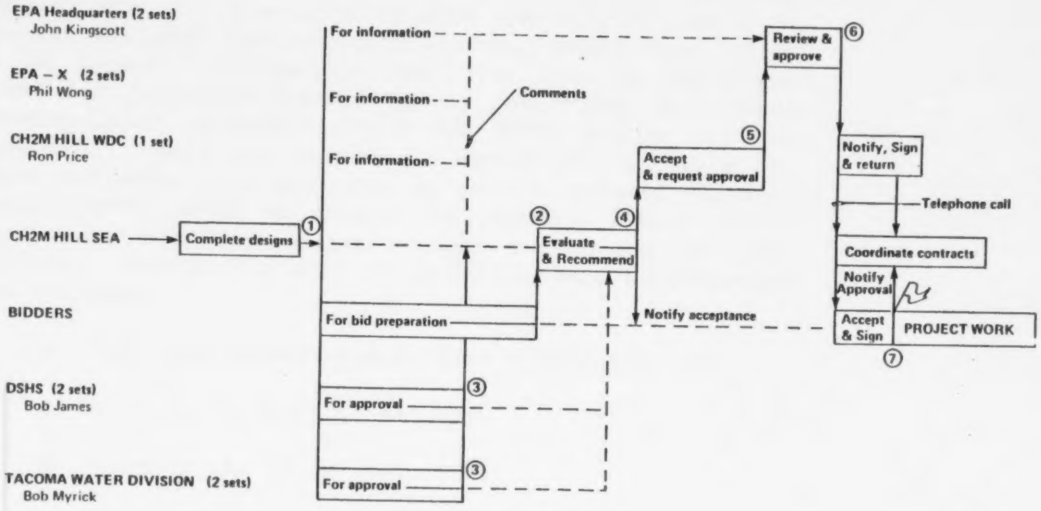
- A decision was made to include a feature to direct discharge to either the bay or the reservoir. At this point the Department of Ecology had maintained a discharge limit of 10^{-6} risk factor (based on aquatic life). With the design standards and operating limits known to date, treated effluent appeared to be within the limits needed for discharge to the drinking water system.

The permit issues continued to be clarified in February. The Department of Ecology indicated that a modification of the water quality standards would be acceptable, but that the 10^{-6} risk factor (from eating fish) would be the criteria for discharge. (The 10^{-6} limit for TCE was 8.85 ppb (ug/l); there was no published limit for 1,1,2,2-tetrachloroethane.) The representative from the Tacoma-Pierce County Health Department, who worked closely with Department of Ecology on discharge limits, agreed with the Department of Ecology position. Noise levels for operations had been specified for the Well 12A location.

By March, the process, permit and design groups were close to completing their studies. The system design at this time included five identical air stripping towers each with a centrifugal fan and intake silencer and a packed tower. An influent header would bring water directly from Well 12A to the towers, with each tower capable of independent shut-down. An effluent header lead to a junction point from which the flow of water could be directed either to Commencement Bay or to the city's Hood Street Reservoir, where the Well 12A water would undergo at least a sixfold dilution before entering the water distribution system. With the process, design, and permit groups far along in their studies, the review and approval of contract packages by the various government agencies became the critical path item.

Also, by March the regional contractor management team had developed a flow sheet for bidding package review and approval (Figure 15). This sheet facilitated the contractor selection process because deadlines were made clear to those agencies with review and approval responsibilities. This process was not designed to secure any inappropriate approvals from agencies, but rather was to reduce delays by early identification of problems and by stressing the need to make reasonable shortcuts in paper handling. The process illustrated in Figure 15 is summarized below:

- Completed bid packages (from the regional contractor) were distributed to:
    - EPA Headquarters, Region X, and the Superfund Project Management Office for information
    - To bidders for bid preparation
    - To DSHS and the Tacoma Water Division for approval.
- Comments were to be submitted as early as practical, and changes affecting the bid packages would be approved by DSHS and the water department before modifications would be sent to the bidders.
- Bids were to be returned to and evaluated by the regional contractor. Documentation for award approval by EPA Headquarters, and for review by the Zone Project Management Office, were to be prepared by the regional contractor.
- Successful offerors were to be notified and informed of the new timeframe and required documentation.



SUBCONTRACTING
BID AND AWARD PROCESS

CONTRACT NO. AND TITLE		SMALL BUS.	BIDDERS	① BID PKGS. OUT	② BIDS IN	③ APPROVALS AND COMMENTS DUE ◆	④ EVALUATION COMPLETE	⑤ ACCEPTED	⑥ EPA APPROVAL	⑦ NOTICE TO PROCEED
3.5K5 – PT	Packed Towers	0	6	7 Mar	15 Mar	16 Mar	18 Mar	21 Mar	25 Mar	28 Mar
3.5K5 – TF	Fan Unit	0	4	8 Mar	16 Mar	17 Mar	21 Mar	22 Mar	28 Mar	29 Mar
3.5K5 – M	Media	2	4	15 Mar	21 Mar	21 Mar	23 Mar	24 Mar	30 Mar	31 Mar
3.5K5 – FP	Fabricated Pipe	2	5	21 Mar	29 Mar	30 Mar	1 Apr	4 Apr	8 Apr	11 Apr
3.5K5 – CC	Construction Contract	2	5	17 Mar	30 Mar	23 Mar	4 Apr	5 Apr	11 Apr	12 Apr

◆ Expected EPA project approval is 16 March.

CONTRACT REVIEW/
APPROVAL DATES

Figure 15. Bid Process Schedule for Well 12A Air-Stripping System Contractor Selection

Source: CH2M Hill 1983-1984

Figure 15: Bid Process Schedule for Well 12A Air-Stripping
System Contractor Selection

Source.

- Work could begin when the appropriate EPA and contractor representatives signed the contract.

In late March, the regional contractor completed a study in support of the permits application process showing that the discharge of 3500 gpm (13,250 l/min) of treated effluent into the city waterway would have little or no impact. Information was also sent to the Puget Sound Air Pollution Control Agency concerning worst case ground-level concentrations of VOCs during system operation. This information is summarized in Table 16. These estimates were generated by an EPA-approved computer model, PTMAX, which calculates the maximum 1-hour ground level concentrations under various meteorological conditions. Assumptions used for modeling were conservative and included:

- Plume and ambient temperature = 55°F (-1.4 C)
- No plume buoyancy or velocity
- Plume height of 50 feet (15 m)
- Total contaminants (40 lbs/day) (18 kg/day) were emitted from a single point.

The worst-case scenario developed by PTMAX showed that the concentrations emitted by the Well 12A system were orders of magnitude below OSHA standards.

Events moved quickly in April, May, and June. These are summarized below:

- April - Contracts were awarded by the regional contractor.
  - A waiver was granted allowing the city to discharge treated effluent to the waterway
- May - Construction of the Well 12A treatment system began
  - A permit was approved by the Puget Sound Air Pollution Control Authority
- June - Public meetings were held
  - Construction was halted because of a plumbers' strike.

Labor difficulties was the one item which could not be anticipated in planning for the project. The Plumbers' Union for the Tacoma/Pierce County area went on strike in June, but work continued on Well 12A because activities

TABLE 16. SUMMARY OF AIR EMISSIONS MODELING INFORMATION

Compound	Influent Concentration ug/l	Removal Concentration ug/l	Emissions Rate (to Atmosphere) lb/day	Ground-Level Concentration 1-Hour (Model) ppm	Ground-Level Concentration 8-Hour (Model)[1] ppm	Ground-Level Concentration OSHA 8-Hour Standard ppm
1,1,2,2-tetrachloroethane	350	307.2	12.9	.0106	.008	5
1,2-trans-dichloroethylene	200	198	8.3	.0118	.0089	200
trichloroethylene	440	435.6	18.3	.0193	.0145	100
tetrachloroethylene	10	10	.4	.0003	.0002	100

[1] Average 8-hour concentration = (0.75) x (average 1-hour concentration)

Source: CH2M Hill 1983h

were being conducted by union plumbers who were not on strike since they were from another local union in another county. The striking union did not picket the Well 12A site until June 13th; there is some indication that this action was designed to gain some publicity for the plumbers' strike. When picketing began, all substantive construction was stopped.

Members of the project team sought to remove the picketers through discussions with various union representatives and politicians. A contractor gate was erected and work resumed, although with instances of common vandalism (e.g., sugar in gas tanks, locks jammed with metal, and fences cut). Work was finally completed on July 18, 1983, with most of the 2-week delay attributed to the plumbers' strike.

The system was tested and started up in August, with actual removal rates of approximately 98 percent (vs. design rate of 88 percent). Treated effluent was sent to the city water distribution system on August 4, 1983. The system continued to operate until shut down for the winter on November 4, 1983.

COST AND FUNDING

Source of Funding

Costs of the initial remedial measure (IRM) were paid jointly by the State of Washington, the EPA, and the City of Tacoma. Through a Superfund State Contract, the EPA was responsible for 90 percent of the cost of the IRM and the State of Washington assumed responsibility for the remaining 10 percent, acting through the Department of Ecology (DOE). In a separate action, the State DOE entered into contractual agreement with the city of Tacoma so that the city and State could jointly pay for the State share of the Superfund contract. Through this agreement the State will pay 10 percent of eligible project costs. The eligible project costs are subject to State approval. The State's contribution will not exceed $574,071. On March 9, 1983, the Board of the City of Tacoma approved by motion the acceptance of the State grant. City monies for the project were provided through passage of Referendum 38 which authorized grant funding to the City of Tacoma.

Little information was available regarding related costs, although it appears that funding for sampling, analysis, and drilling of monitoring wells was paid primarily by the EPA for Superfund activities. Prior to passage of CERCLA, the City of Tacoma paid these costs.

Selection of Contractors

Prime contractors were generally engaged under previously let contracts. EPA's regional contractor, Black & Veatch of Kansas City, Missouri, was authorized on July 29, 1982, by the EPA to begin the Remedial Investigation and Feasibility Study under prior contract to the EPA. Black & Veatch, along with their geotechnical consultant, Woodward-Clyde Consultants, conducted a groundwater investigation detailing subsurface hydrology and examining the contaminant plume. Eleven 160-ft (48.7-m) deep monitoring wells and 10 30-ft (9.1-m) deep soil borings were drilled by Johnson Drilling Company and Kring Drilling Company, both of Tacoma, Washington. These bidders were chosen on the basis of competitive bidding; selected contractors presented the lowest bid. Woodward-Clyde Consultants was also involved with the drilling of 13 wells in the suspect South Tacoma Swamp Area in September 1982, as well as the surface investigation for sources conducted in February 1983. Ecology & Environment, Inc., was contracted by the EPA to investigate sources of contamination of Well 12A found at or near the soil surface. This was considered Phase I of the surface investigation; Phase II, which was an extension of Phase I, was conducted by Black & Veatch.

In January 1983, CH2M Hill replaced Black & Veatch as the regional contractor. CH2M Hill ran bench-scale and pilot studies of proposed remedial actions. Cost analyses and designs were developed and presented to the EPA. Implementation of the IRM was then carried out by subcontractors who supplied components or did the construction. The IRM consisted of four components: the fiberglass towers, the packing media, fabricated pipe, and the fan units. Five separate subcontracts were let for these components and the construction.

Bid packages were sent to prospective bidders and were not advertised due to the very short timeframe necessary for completion of the project. Bids were subsequently solicited from three to five of the most qualified firms. Selection on all bidders was made on the basis of: (1) lowest price; (2) conformance to stated specifications; and (3) capability to render goods and services according to the specified schedule. CH2M Hill selected the prospective bidders based on contacts made during the engineering and design phase, records of past performance on other projects of similar nature, and catalogue information. All contracts were fixed price type.

The five towers were constructed by Ershigs, Inc., of Bellingham, Washington. Ershigs was noted for being a skilled manufacturer of high-quality fiberglass vessels of the size and type required. The towers were shipped 150 miles (241 km) to the site by Bellingham Transfer Co., a local concern.

The 2018 cubic feet (57.14 m^3) of Koch flexi saddles used for packing was supplied by Maltby Equipment & Supply of Woodinville, Washington. Maltby Equipment & Supply was selected primarily based on its ability to supply the media within the specified timeframe, as it was the third lowest bidder with a bid approximately 35 percent higher than the lowest bidder. The difference in time of delivery between the lowest bidder and Maltby amounted to about 5 weeks. Maltby was also noted to be a certified women-owned minority business enterprise. Out of the five contractors who submitted bids for the prefabricated pipe, Maltby Equipment & Supply was also selected. In this case, however, Maltby submitted the lowest bid. Maltby Equipment & Supply prefabricated pipe for the Seattle Metro and received good references regarding workmanship and schedule in the completion of this project.

Responses on bid packages for the fan units were received from three firms. Norby Company was awarded this contract on the bases of lowest overall price and capability to deliver on schedule. Fan units consisted of fans and silencers.

Construction of the towers can be broken into five parts: mobilization, concrete work, earthwork, electrical work, and mechanical work. J.P. Francis and Associates, a general contractor, submitted the lowest bid and was chosen for construction. Francis, established since 1970, was selected on the basis of its general contracting experience. Subcontracts under Francis were as follows:

- Como Contractors of Kent did earthwork. Como and Francis had worked together previously.
- Long Painting of Seattle did painting. Long is experienced in industrial and outdoor painting.
- Carl T. Madsen of Tacoma did electrical work. Madsen, an experienced industrial electrical contractor, worked with Francis previously.

All construction contractors are small business firms; J.P. Francis is also a minority-owned business.

Contractors involved in chemical analyses of samples include Weyerhauser Technical Center in Federal Way, Lauck's Lab in Seattle, a CH2M Hill lab in Oregon, the Am-Test Laboratories of Seattle, Bennett Labs of Tacoma, Spectrix Corporation, and West Coast Technical Services. Information relevant to selection of analytical laboratories was unavailable.

Project Cost

Remedial Investigation/Feasibility Study

Cost information concerning early activities associated with Well 12A is not available because early efforts of the Remedial Investigation and Feasibility Study (RI/FS) included three areas that are now being considered as separate Superfund sites. The expanded RI/FS, which was specific to Well 12A, had an estimated cost of $85,000. The expansion included installation of 11 observation wells to a depth of 160 ft (48.7 m), 10 30-ft (9.1-m) deep soil borings, sampling of new and existing wells, and analysis of data and correlation with the previous RI/FS. Actual costs came out to be approximately $126,130. Cost overruns were associated with unexpected costs of sampling, logging samples, oversight, and administration. Details of the overrun are included in Table 17. Other cost itemization on the RI/FS was not available as this was covered under a lump-sum bid of the REM contract.

TABLE 17. ITEMIZED ESTIMATES OF COST OVERRUN

Item	Amount
Direct Labor	
Prime Contractor	$ 4,170
Subcontractor	12,154
Overhead	4,241
Drlling subcontract	13,538
Other Direct Costs	4,300
Fee	2,727
TOTAL	$41,130

Source: Black & Veatch 1982b

Covered in the estimated cost overrun for direct labor were items such as property access, review of other lab data, contractor-subcontractor coordination, additional sampling, meetings, management, safety programs, additional drilling time, and overtime. The overrun for the drilling subcontract was split almost evenly among increases in costs of materials, differences between Work Plan estimates and actual bid amounts, and Washington State sales tax. Other direct costs included vehicle rental, sample shipment, travel and per diem, postage, and telephone costs. Not included were funds spent for work plan preparation totalling $18,336.

Initial Remedial Measure

Costs of construction and implementation of the Initial Remedial Measure are detailed in Table 18. Subcontracted items, covering both materials and construction amounted to a total of $763,905, or about 81 percent of the total cost. Of the subcontracted items, construction and materials accounted for 39 percent and 61 percent of the costs, respectively. Modifications of the contracts causing increased costs were due to field changes necessary during construction, a strike by the Plumbers & Fitters Union, and changes in design to improve operation and maintenance of the system. Four cost overruns increased costs of fixed price subcontracts by about 11 percent.

Unit price of fans in Table 18 includes cost of both the fan unit and the silencers; these were originally bid at $31,627 for the fan units and $4,275 for the silencers, totalling $35,902. Reasons for the lowered price are not clear from the documents. Itemization of construction activities is included in Table 19. Two cost overruns were incurred due to a strike. Increased security was required to preclude damage to the construction in process. Shipment and off-loading of two towers was delayed by picketers at the site. These costs and modifications of the towers done at the time of construction increased costs of construction by $6,118.12, an amount which is not included in Table 19.

Operation and Maintenance

Costs of operation and maintenance include electrical usage and system standby costs, which totalled about $7,000 per month during the operating months and about $3,000 per month during non-operating months. Operation and maintenance costs for a period from August 1, 1983, to February 1, 1984, are listed in Table 20.

TABLE 18. COSTS OF INITIAL REMEDIAL MEASURE AT TACOMA WELL 12A

Subcontracted Items

Item	Quantity	Cost	Unit Price
Towers	5	$205,818	$41,163/tower
Fans	5	34,452	6,890/fan
Media	2018 cu. ft. (57.14m^3)	205,760	101.96/cu ft 3600/m^3
Pipe	N/A	17,875	
Construction*		300,000	

Consultants	
Health & Safety Plan, Training & Monitoring	5,000
Soil & Concrete Lab	300
Analytical Lab	10,800
Direct Labor 2320 hours incl. 256 OT hours	37,813
Labor Overhead .41 x 37,813	15,503
Other Direct Costs:	
Power Supply Fee	2,000
Air Discharge Permit Fee	410
Building Permit Fee	6,870
B&O Tax	5,200
Computer	500
Photo/Print	700
Typing Equipment	500
Package Express	165
Telephone	375
Travel	900
Per Diem	285
General and Administrative Expense	45,754
Fee or Profit	51,153
TOTAL COST	$948,133

*Itemization of construction activities is in Table 19

Source: CH2m Hill 1983p

TABLE 19. COST OF CONSTRUCTION COMPONENTS

Item	Amount
Mobilization	$ 8,500.00
Concrete Work	60,000.00
Earthwork	30,000.00
Electrical	25,000.00
Mechanical	105,500.00
TOTALS	$229,000.00

Source: CH_2M Hill 19831

TABLE 20. OPERATION & MAINTENANCE COSTS OF TACOMA WELL 12A AERATION TOWERS

Item	Amount
Labor	$13,413.54
Overhead	2,503.62
Transportation	537.10
Private Lab Tests	17,704.02
Electricity	8,144.84
Miscellaneous Labor	55.25
Miscellaneous Materials	182.85
Public Works Lab Tests	6,695.00
TOTAL	$49,236.22

Source: Tacoma DPU 1983b

PERFORMANCE EVALUATION

The objectives of the treatment system enacted at Tacoma Well 12A, and against which performance must be evaluated, were:

- To permit operation of the well to block the spread of contaminants
- To supply drinking water when treated effluents are within applicable water quality standards
- To partially clean up the aquifer.

To block the spread of contaminants, the treatment system for Well 12A had to operate such that the well could pump, treat and discharge effluent (either to the city waterway and then to the bay, or to the Hood Street Reservoir) whenever other wells in the system were operational. In order to operate over a period of time, discharge limits were placed on treated effluent as follows:

- A maximum of 15.5 pounds/year (7.03 kg/yr) of 1,1,2,2-tetrachloroethane to the Hood Street Reservoir
- Average concentration of 50 ppb (ug/l) or less of 1,1,2,2 tetrachlorothane to Commencement Bay
- The maximum concentration of VOCs allowed for discharge to Commencement Bay was 100 ppb (ug/l).

Therefore, the treatment system had to operate so that less than the maximum quantity of 1,1,2,2-tetrachlorothane would enter Hood Street during the period when the well field was operating, and so that effluent limits are within acceptable ranges. If the 15.5-lb (7.03-kg) limit was reached, water could no longer be discharged to the drinking water system, and if the concentration limits were exceeded, the well would be forced to shut down.

The Well 12A system was in service from August 4, 1983 to November 4, 1983, and the efficiency of the treatment system was approximately 98 percent. Calculations made in October 1983 showed that effluent from the well could be sent to the Hood Street Reservoir for an additional 245 days (the system had been operating for approximately 60 days) before the 15.5-lb (7.03 kg) limit was reached. In addition, the effluent discharged never rose above the 50 ppb (ug/l)limit set as the average for discharge to Commencement Bay. Figures 16 and 17

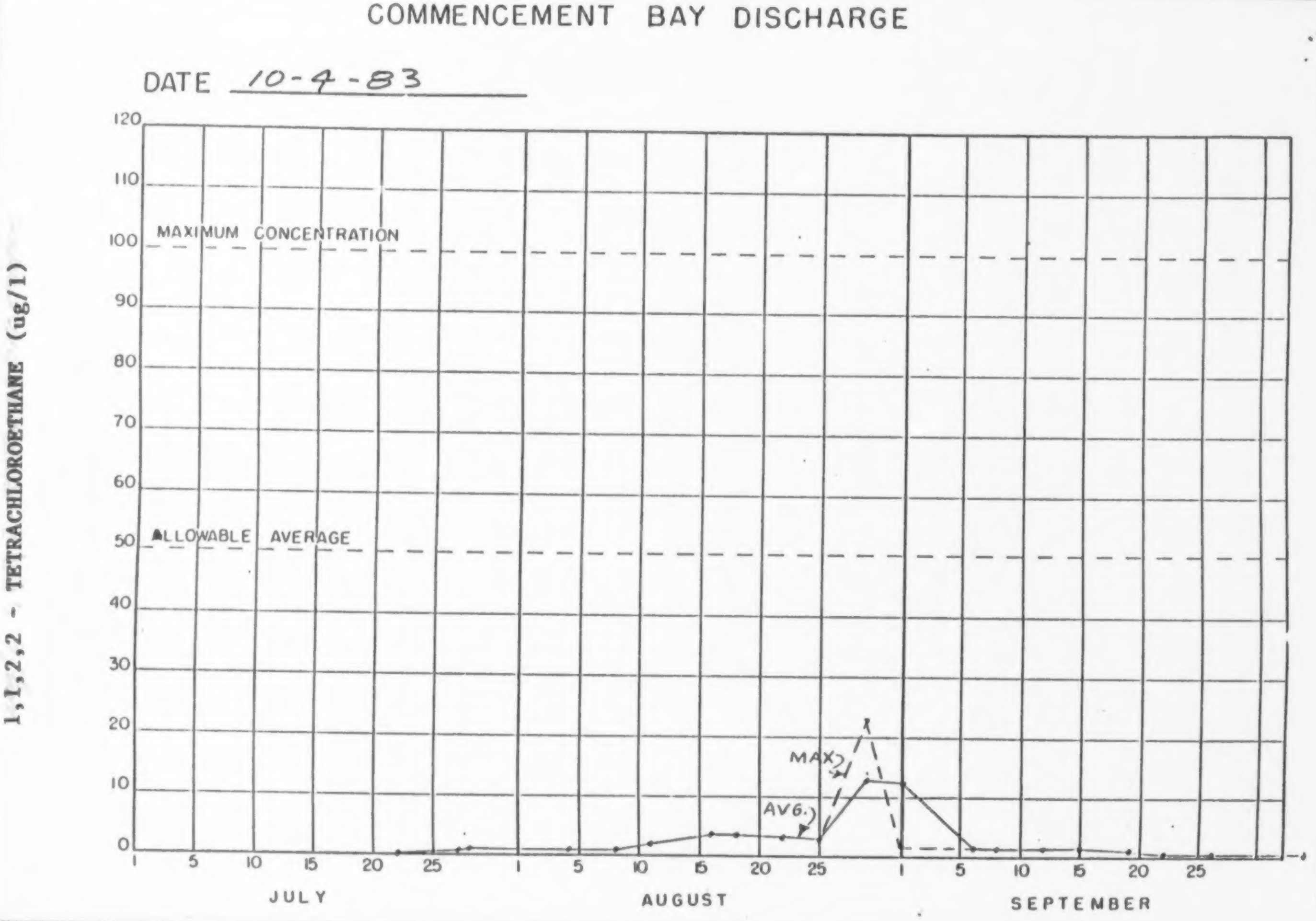


Figure 16. Effluent Condentrations for Treated Well 12A Water Discharged to Commencement Bay

Source: Tacoma DPU 1983e

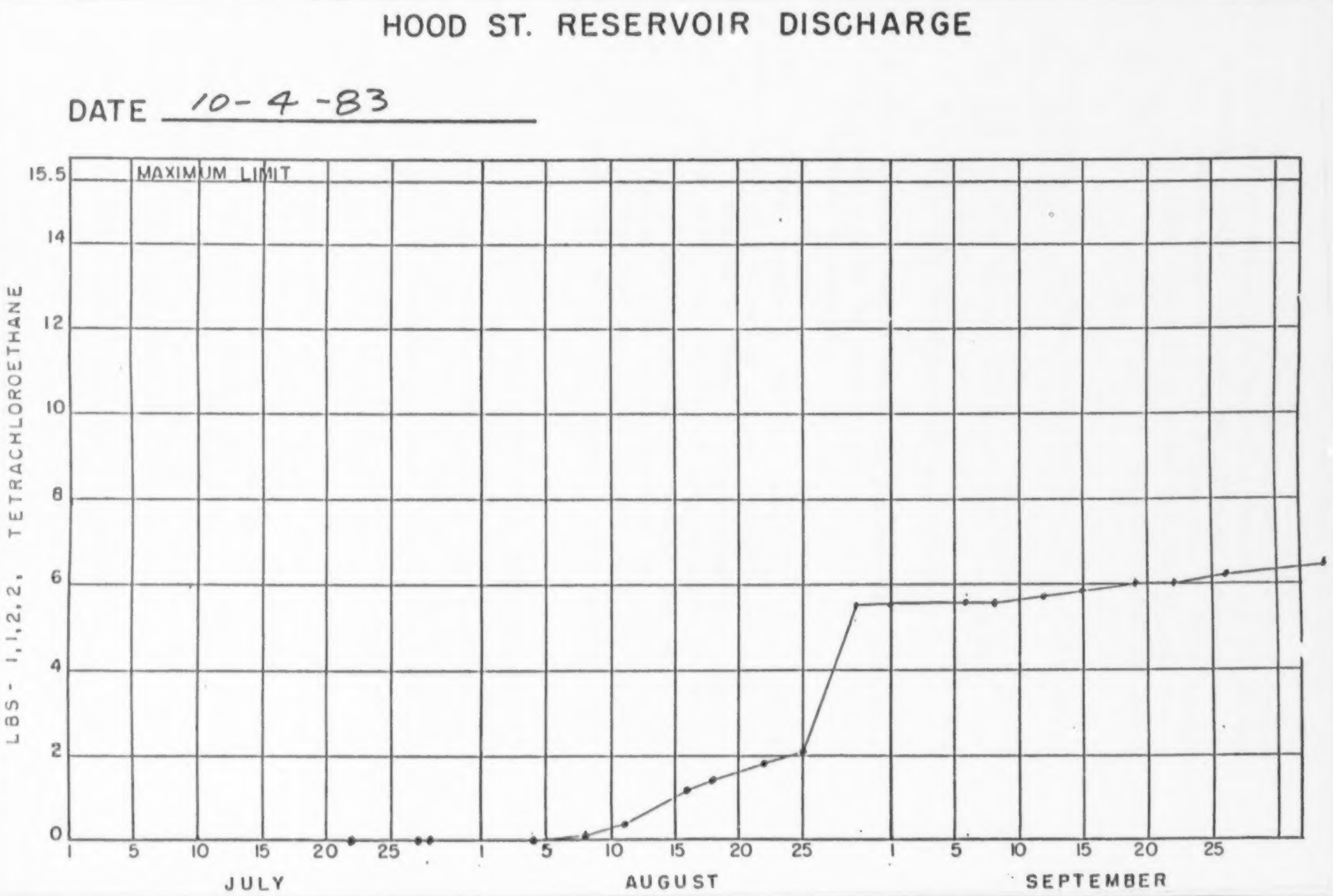


Figure 17. Total Load Discharge to Drinking Water Distribution System

Source: Tacoma DPU 1983e

illustrate the effluent levels for Well 12A during the operational period. This record of performance indicated that the system could be operated for periods much longer than required to protect other wells and still be within the discharge limits. Because the effluent concentrations were low, treated water could be discharged to Hood Street Reservoir and into the city's distribution system for a period much greater than required to meet drinking water supply needs.

Therefore, the system accomplished two of the three stated objectives:

- The system permitted Well 12A to operate for periods while the well field was in operation, thus blocking the spread of contaminants.
- The system treated Well 12A groundwater such that effluent could be discharged to the Hood Street Reservoir if needed.

The system appears to be meeting its third objective--partially cleaning up the aquifer--but sampling data are only available from a single pumping season. Figure 17 shows that the levels of contaminants in Wells 9A and 11A were dropping during the period the Well 12A system was operating. This indicates that the contaminant levels are dropping, but no quantitiative analysis can be made regarding the amount of cleanup the aquifer has undergone.

Although it appears that the Well 12A system is meeting all of its objectives, influent levels have been much lower than anticipated. The system was designed to handle an influent concentration of 1000 ppm (mg/l) (total VOC), yet influent concentrations have been substantially less. An increase in the concentrations of contaminants at CBW-10 (north of 12A) indicates that the plume is moving toward Well 12A. This, plus the concentrations found at the suspected primary source site (37,000 ppb (ug/l) of 1,1,2,2-tetrachloroethane), supports the contention that the concentrations in the influent will increase during the next pumping season. If the system can maintain its 98 percent efficiency at higher concentrations, however, there should not be a problem with the system remaining in operation.

There have been minor problems with the Well 12A treatment system during its first 3 months of operation:

- A power outage shut down two towers for 1 day although water continued to flow through all five, resulting in a 10-fold increase in the amount of VOCs in the effluent. Procedures were modified so that the water will be diverted to the bay, or the well will be shut down, in the event of another power failure.

- A solvent, used in coating the interior of piping, was detected in the effluent. The problem corrected itself after several days and the explanation is that the coating may have been improperly cured.

- Improperly tightened belts squealed when the fans started up, exceeding noise standards and causing some irritation to nearby residents. The contractor called to properly adjust the belts and discovered that they were not properly rated for the machinery. The belts were tightened, eliminating the start-up problem, and properly rated belts were obtained and stored at the well site as backups.

The impact of the system on the local air quality is below that anticipated. Table 21 shows results of air emission tests with all concentrations below that anticipated.

TABLE 21. AIR EMISSIONS FROM TACOMA WELL 12A TREATMENT SYSTEM

Compounds	Results (ppb)(ug/1)/hr EPA #23 Method	NIOSH #127 Method
1,1,2,2-tetrachlorthane	1.34	8.93
1,2-trans-dichloroethylene	<1.0	<24.8
trichloroethylene	11.5	15.9
tetrachloroethylene	3.3	2.02

Source: CH2M Hill 1983p

The performance of the Well 12A treatment system is summarized below:

- The towers have operated at better than design efficiency, thus the system could operate for longer periods of time to clean the aquifer.
- Water quality in selected wells has improved due to treatment system operations.
- Significant problems leading to system shutdown, or exceeding water quality standards, have not been encountered.

Factors leading to the success of the treatment system are summarized below:

- The hydrogeologic system was sufficiently characterized so that plume behavior could be anticipated (even though the source had yet to be identified).
- The multi-track project development approach concentrating on critical path items was a key factor in meeting the completion date (except for the 2-week delay because of strike).
- The cooperation of the various regulatory agencies (i.e., in evaluating documents) was a key factor in meeting the scheduled start date.
- The pilot-scale tests and supporting models were invaluable in the proper design of the system.
- The use of conservative estimates and margins for error led to the implementation of a system that exceeds design parameters.
- The cooperation between the two EPA contractors (Black & Veatch, and CH2M Hill) during the change-over in zone contractor assured that the project schedule could be met. Without this smooth transition, meeting the August start-up date would have been difficult.

The implementation of the initial remedial measure at Well 12A involving construction of an air stripping system is justified by the proven success of the system in terms of meeting stated objectives.

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TAYLOR ROAD LANDFILL

SEFFNER, FLORIDA

INTRODUCTION

NCP References

The Taylor Road Landfill site, located in northeast Hillsborough County, Seffner, Florida, is a sanitary landfill formerly owned and operated by Hillsborough County (Figure 1). The 42.5 acre (17.2 ha) site, one of three landfills within a County owned area of approximately 278 acres (113 ha), lies east of an inactive 10.6 acre (4.3 ha) "Borrow Pit Expansion" landfill site and southeast of the currently active, 64 acre (25.8 ha) "Hillsborough Heights" landfill. Although the Taylor Road landfill was originally intended for the disposal of municipal refuse only, unknown quantities of hazardous wastes from industrial and residential sources, including solvents, paint thinners, halogenated organics, insecticides, herbicides, fungicides, oils, sludges, and other potentially hazardous wastes, were deposited at this site. During the period when the landfill was active, soil and groundwater samples collected at the site were found to contain concentrations of volatile organic compounds and metals above acceptable safe drinking water standards. Analysis of samples collected from private drinking water wells indicated that contamination was also present down gradient from the Taylor Road site. After the Taylor Road site was closed, methane gas was detected off-site near adjacent residences.

300.65(a)(2)
contamination
of drinking water
supply

To handle county needs, the Borrow Pit Expansion and the Hillsborough Heights landfills commenced operations after closure of the Taylor Road site. Eventually, the smaller Borrow Pit Expansion site was filled and was also closed. The focus of remedial and enforcement action in this case is on the two closed sites, with primary emphasis on the Taylor Road site.

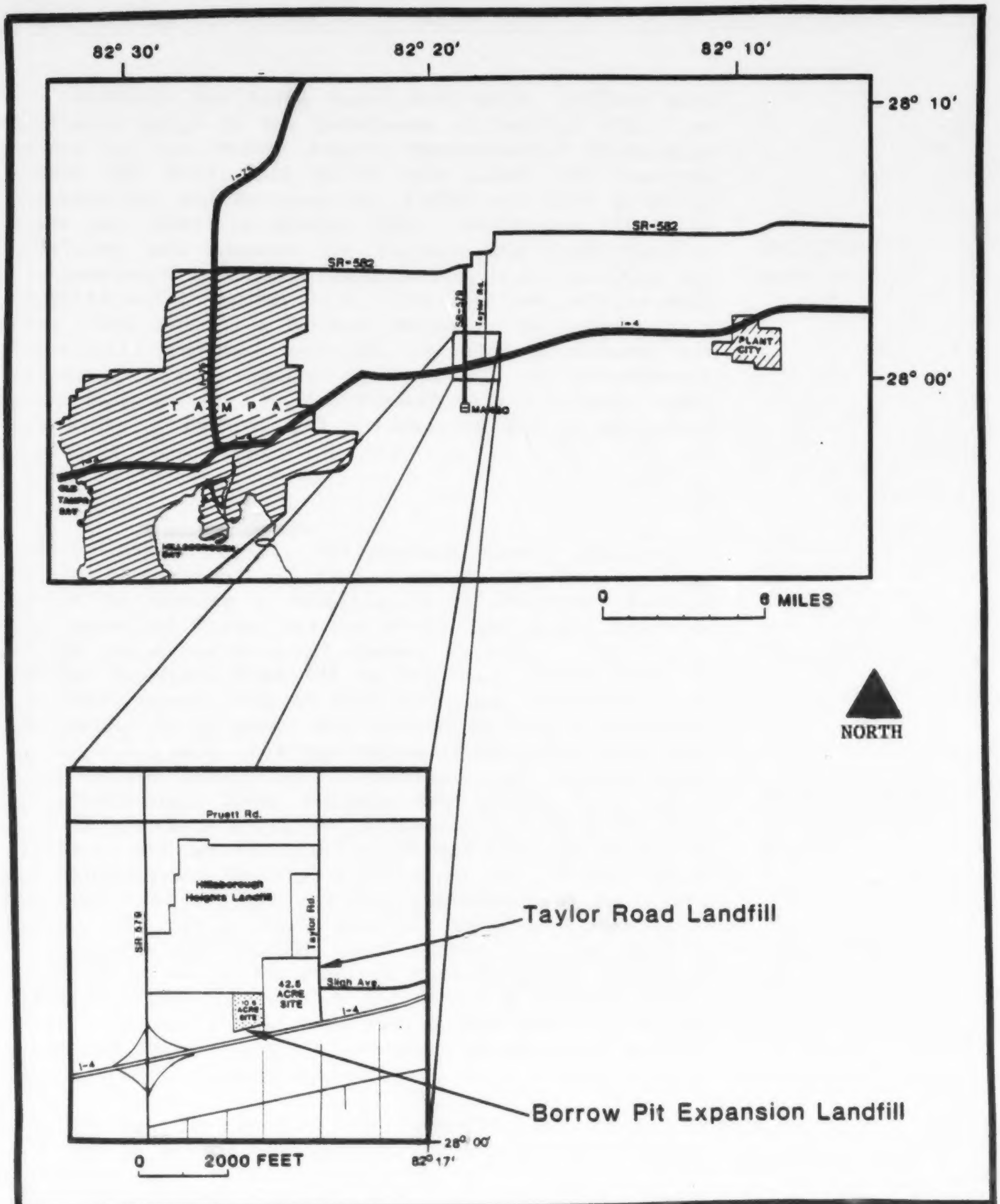


Figure 1. Site Location

Source: Engineering-Science 1983

Although the State later intervened, actions were initially taken by the Department of Justice (DOJ), on behalf of the United States Environmental Protection Agency (US EPA). DOJ filed suit under the Resource Conservation and Recovery Act (RCRA) and Safe Drinking Water Act (SDWA) in October 1980. In January 1982, the complaint was amended to include the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and 18 months later, the case was settled with each party signing a consent decree. The agreement, a $2 million remedial program, includes a methane gas collection and monitoring system, a groundwater monitoring network, an improvement in the present cover and drainage system, and a provision for an alternate community water supply.

300.62(a)
state role

Background

On May 15, 1976, Hillsborough County obtained a Florida Department of Environmental Regulation (DER) permit to develop a landfill in an abandoned Florida Department of Transportation (DOT) borrow pit approximately 10 miles east of Tampa, Florida. The site, bounded by State Road 579 to the west, Taylor Road to the east, Pruett Road to the north, and Interstate 4 to the south, is situated near several private residences. Within a 1.5 mile (2.4 km) radius of the site, there are also various commercial, industrial, and institutional establishments. These include two mobile home parks with 13 trailers each; an elementary school 4,000 feet (1,219 m) due north along Taylor Road with approximately 800 students and faculty; a livestock auction yard about 500 feet (152 m) south of the landfill; and an orange grove. The Taylor Road Landfill, serving a population of approximately 192,000, overlies the Floridan Aquifer, a source of water for much of Florida and a principal drinking water source for the County's 800,000 residents. Within 1 mile (1.6 km) of the site, there are about 580 private wells also using the Floridan Aquifer as a source of potable water.

300.68(e)(2)(i)
(A) popolation
at risk

During the period the landfill was open, it received up to 800 tons per day (726 metric tons/day) of municipal solid waste. Permit conditions required that each day's waste deposits be covered with 6 inches (15 cm) of soil material. Hillsborough County operated the site from 1976 until 1980. The problems associated with the Taylor Road Landfill came to the attention of the State and US EPA Region IV in late 1979.

Synopsis of Site Response

The first action taken at Taylor Road was initiated after EPA discovered that groundwater in the area was contaminated. EPA immediately sent warnings to residents and private well owners to discontinue use of their water supply and later contacted both state and county officials about the problem. The response by the County was threefold. First, the county followed EPA and Hillsborough County Environmental Protection Commission recommendations to begin delivery of bottled water to affected residents. Approximately 95 households and businesses in the area along and north of US 92 were included in the program. Second, the county hired groundwater specialists to investigate well contamination, to establish a more intensive hydrologic investigation and, if necessary, to design a remedial action plan. Third, after a report submitted in January 1980 confirmed EPA's findings of contamination on-site, the County offered to extend the municipal water line system to those users receiving bottled water who desired a permanent alternate water supply. Thirty-eight locations accepted the offer.

300.63(a)(2)
government
investigation

300.64(a)(2)
identification
of source and
nature of
release

The Florida DER's response included:

- Requiring the County to obtain a permit to close the site
- Requesting a copy of the Report on Contamination
- Requiring the County to develop a long-term groundwater monitoring plan.

Original closeout procedures for the Taylor Road Landfill site, carried out in February 1980, included placing several feet of soil over the area. A clay cover was also planned for installation in the future. At the same time, the Borrow Pit Expansion landfill commenced activity under a DER emergency temporary operating permit.

300.68(e)(1)
initial remedial
measures

The County's contractors continued their program to determine the full areal extent, concentration, direction and rate of movement of the plume and, if possible, the specific source of contamination. An April 28 through May 1, 1980 meeting between Hillsborough County, their groundwater consultants, and DER was held to discuss the news that wells farther from the area previously defined to be contaminated contained volatile organic compounds in concentrations similar to closer wells sampled earlier. The County, learning that the contaminant plume had migrated, extended the bottled water distribution program to 180 locations, including residences with wells south of US 92 and north of Old Hillsborough Avenue. The County also hired a toxicologist to assess the potential health hazards of consuming area well water. Final plans for capping and surface grading were submitted in May, but had to be revised two months later because rainwater that supposed to be channeled into on-site or adjacent percolation areas often remained on the site, causing surface ponding and obstructing progress on the clay cap.

In June 1980, EPA's consultants concluded that the Taylor Road Landfill was the source of the groundwater contamination problem and, in July, added that the contamination might also be coming from the Borrow Pit Expansion site. Meanwhile, the County's refuse had to be deposited somewhere and, consequently, even though the problem remained to be corrected, the state granted Hillsborough County another emergency permit in July 1980 to open 41.5 acres (16.8 ha) of the Hillsborough Heights landfill.

300.68(e)(1)
initial remedial
measures

During the summer of 1980, capping and final grading at the Taylor Road Landfill site continued, drainage ditches around the south side of the Borrow Pit Expansion site and the perimeter of Taylor Road Landfill were constructed, and a response to the gas migration problem was initiated. Planned gas controls included an on-site, experimental gas venting system that consisted of an interconnecting series of pipe vents with some of the vents being flared and off-site gas monitoring by the County's fire department. By October 1980, the Borrow Pit Expansion site had reached capacity. Another closeout permit for the Borrow Pit Expansion site was issued October 11, 1980, under Chapter 17-7 of the Florida Administrative Code. Under this closure plan, the State required monitoring and control plans for "gas of decomposition", a final cover of at least 18 inches (46 cm) of compacted soils plus 6 inches (15 cm) of top soil for vegetation, revised drainage plans, and completion of all closeout procedures by March 1981. Excessive spring rains continued to cause delays in progress, but in June 1981, as the Hillsborough Heights site expanded from 41.5 to 64 acres (17 to 26 ha) under a second emergency authorization, a 3 to 10 foot (1-3 m) clay soil cover over the two closed sites was completed and the County's Department of Solid Waste finished installing the gas ventilation system.

The toxicologists submitted a final report to the County in April 1981 and, based on their findings that there were no potential adverse health effects, the County took the position that contamination was decreasing over time, discontinued service of bottled water on July 23, 1981, and planned but did not install, a permanent water supply. EPA believed that contamination was not decreasing and, therefore, was uncomfortable with the decision to allow residents to return to drinking well water. As a result, US EPA's Office of Waste Programs Enforcement (OWPE) requested their Environmental Criteria and Assessment Office (ECAO) to perform a carcinogenic, quantitative risk assessment of well water near the Taylor Road Landfill and south of US 92, and retained their own contractor to determine the route of contamination. In September, the EPA Field Investigation Team (FIT) performed a site investigation. Additional sampling from a December 1981 hazardous waste site inspection indicated similar results to those of the EPA ECAO's March 1982 final health hazard report. The results indicated that some of the wells still contained concentrations of pollutants unacceptably high in terms of risks from lifetime exposure.

300.68(e)(2)(i)
extent of threat
to health, welfare,
or environment

It was suspected that the cover had not been an efficient means of reducing leachate production, and thus, a hazard still existed. In January 1982, EPA amended their complaint to include CERCLA Section 106(a) and asked the County to evaluate the effectiveness of the cap and cover in controlling water percolation and in preventing erosion. The new complaint also asked Hillsborough County to abate methane gas release and to provide a permanent source of drinking water to affected County residents. Pursuant to the consent decree entered into Federal Court on October 7, 1983, the County upgraded a designated area of the cap and the drainage ditches along the perimeter of both landfills.

300.68(c)
administrative
process

Two actions were initiated to overcome the methane gas problem. First, the County planned on expanding the existing gas ventilation system, but in October 1983, their gas control consultants determined that the structure, installed without formal design and for ventilation purposes only, was ineffective as a control. An entirely new collection system, consisting of 42 gas recovery wells, a blower facility, and a flare station, was proposed. The wells and blower facility were installed in March 1984 and the flare station was operable in July 1984. The second part of the response was an off-site methane gas monitoring system. Thirty-two wells were installed by April 1984 and the first sampling for consent decree compliance was performed in September 1984.

Because groundwater contamination dissipated, but was not eliminated, the consent agreement included a long-term groundwater monitoring program. The first water quality sampling was performed in September 1983 from 10 existing wells. In the near future, three of these wells will be replaced. Locations of two of the new wells have been agreed on, while one location remains to be decided. All three are expected to be installed and ready for the fall 1984 sampling.

On November 27, 1983, the County sent letters to residents in the area of contamination offering to connect them to a municipal water system. The area residents were given two months to respond to the offer. A permanent water supply will be extended to these residents as a final response measure. The main water lines are expected to be completed with hook up to 550 households by December 1984. Additionally, the consent decree requires that the "Days Inn" well, part of the County's water system which was found to be contaminated, be removed from service. A new well and a pumping system not required by the consent decree were determined necessary to increase pressure for the mains, and thus had to be installed. By November 1984, the new well had been installed; however, it was not immediately placed on line because the design of the pumping system had not yet been completed.

SITE DESCRIPTION

Surface Characteristics

Gently rolling hills and karst topography are dominant in the site area. The Taylor Road Landfill is situated along a north-south trending ridge, which ranges in elevation between 80 feet (24 m) and 120 feet (37 m) mean sea level (MSL). This ridge reflects a high area in the underlying limestone bedrock. Adjacent to the site are depressions in the topography (sink holes) due to the solubility of the underlying calcareous bedrock. A large, steep-sided sink hole is located approximately 2,500 feet (762 m) northeast of the site. This sink hole is approximately 50 feet (15 m) deep. Another steep-sided sink hole, comparable in size, is located within 1 mile (1.6 km) to the southeast. Other circular topographic depressions in the area are fairly shallow at the surface and appear stabilized; these are probably sink holes that have been infilled over time. Buried or remnant sink holes that breached the basal clay were reported during the excavation of the 10.6 acre (4.3 ha) borrow pit adjacent to the Taylor Road Landfill. Approximately one buried sink hole per acre was encountered breaching the basal clay at this site.

300.68(e)(2)(i)
(D) hydrogeological
factors

There is no perennial natural surface water drainage system at the site. Precipitation generally runs off the gently rolling hills and either collects in natural depressions and infiltrates into the soil, or randomly flows into area streams. Presently, surface runoff from the Taylor Road Landfill is collected in drainage ditches and routed to a settlement basin west of the landfill area.

Soils in the vicinity of the Taylor Road Landfill consist of relatively clean, well-sorted silica sand, and range in depth from 5 to 15 feet (2-5 m). The high sand content and the annual precipitation are primarily responsible for these soils being classified by the Soil Conservation Service as psamment intergrades to orthods (USDA 1975). These native soils have high permeabilities and are excessively well drained. As a result, most precipitation will infiltrate to lower zones rather than becoming runoff. This condition also contributes to the lack of a well-defined perennial surface drainage system.

300.68(e)(2)(i)
(E) climate

The climate in the site area is humid with an annual average temperature of 72° F (22.2°C). The normal daily minimum temperature ranges from a low of about 49°F (9.4°C) in January to a high of about 72°F (22.2°C) in August. The normal daily maximum temperature ranges from a low of about 74°F (23.3°C) in January to a high of about 92°F (33.3°C) in August.

Normal annual precipitation is approximately 53.5 inches (136 cm). Precipitation is generally greatest during the month of August and least during November. There was a period of deficient rainfall in the area from 1970 through 1978 during the early operation of the landfill. Figure 2 illustrates the yearly cumulative departure from normal precipitation between 1950 and 1983. Downward trends in the curve indicate below normal precipitation and upward trends indicate above normal precipitation. This figure also shows that annual precipitation has been below normal much of the time since the Taylor Road Landfill was first operated.

300.67(c)(6) weather conditions

Hydrogeology

The Tampa and Suwannee Limestones are the uppermost bedrock units in the vicinity of the Taylor Road Landfill. The dominant composition of these units are limestone and dolomitic limestone and have a combined thickness of 200 to 250 feet (61-76 m). Underlying the Suwannee Limestone is the Ocala Group. This group ranges in thickness from 150 to 200 feet (46-61 m) and is composed primarily of soft limestone. Beneath the Ocala Group are the Avon Park and Lake City Limestones. These formations, having a thickness of approximately 700 feet (213 m), are also composed of limestone and dolomitic limestone. Figure 3 illustrates the stratigraphy in the vicinity of the Taylor Road Landfill.

These formations comprise the Floridan Aquifer, the major water supply aquifer in Hillsborough County and other areas of South Florida. Many area residents south of the Taylor Road Landfill obtain their water supplies from this unit. Rocks of low conductivity in the upper part of the Ocala Group restrict the vertical movement of water (Menke, et al. 1961) within the aquifer. Because of this low vertical conductivity, the Tampa and Suwannee limestones form one hydrologic unit and the formations below the Ocala Group form another hydrologic unit. However, the hydrologic connection between these units by way of joints and solution openings in the Ocala Group results in these units being considered as a single aquifer.

300.68(e)(2)(ii) extent of substance migration

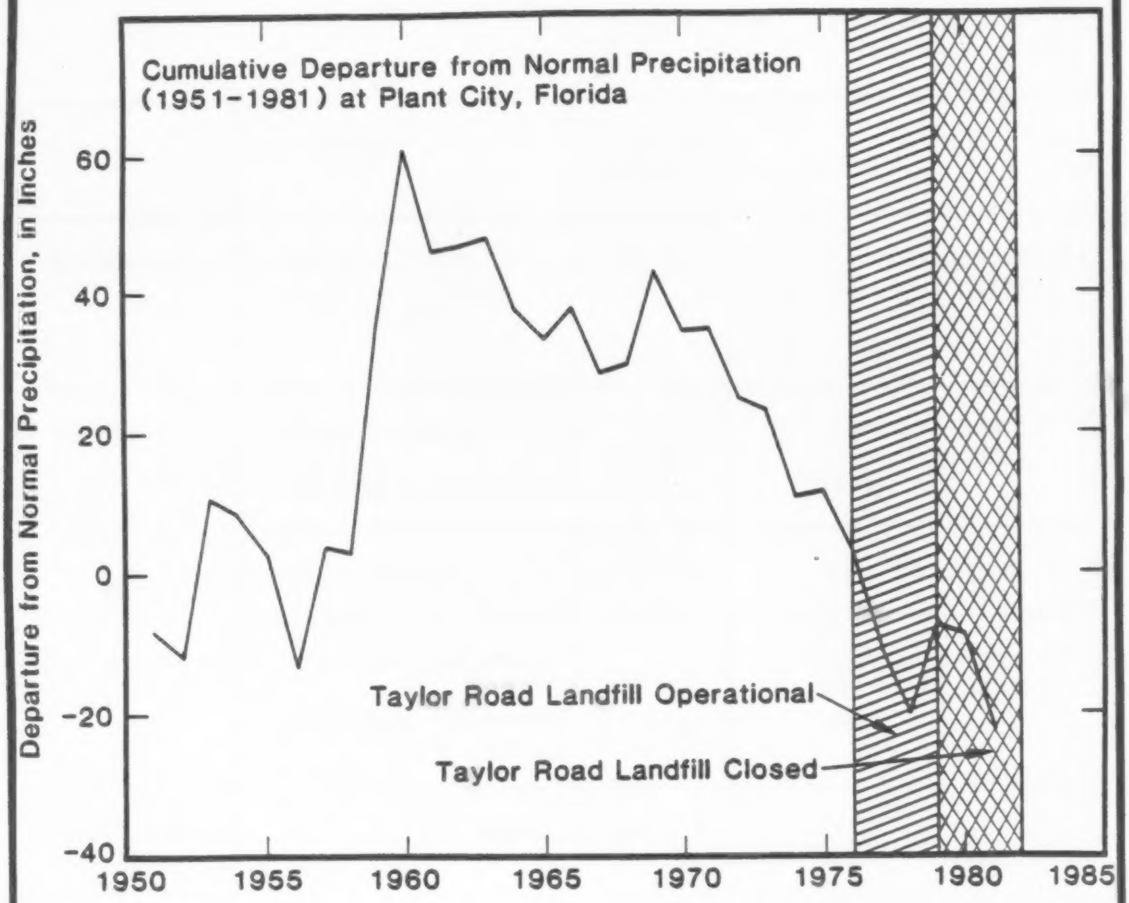


Figure 2. Cumulative Departure from Normal Precipitation

Source: EPA 1983

System	Formation	Thickness (feet)	Lithology
Quaternary	Unconsolidated deposits, undifferentiated	10-120	Sands, clayey sands and sandy clays
Tertiary	Tampa Limestone Suwannee Limestone	200-250	Limestone and dolomitic limestone
	Ocala Group	150-200	Soft limestone
	Avon Park Limestone Lake City Limestone	700	Limestone and dolomitic limestone
Early Tertiary age rocks and older	Not investigated		

Figure 3. **Generalized Stratigraphy in the Vicinity of the Taylor Road Landfill**

Source: Engineering Science 1983

Bedrock of Early Tertiary Age and older ages underlies the Lake City Limestone. These units are not considered hydrologically important by hydrologists because of their stratigraphic position relative to the site and because they contain saline water and are not a potable source.

The unconsolidated Quaternary deposits overlying the limestone units in the vicinity of the Taylor Road Landfill are comprised mainly of sands, clayey sands, and sandy clays. The sandy material is predominantly at the surface and ranges in thickness from 10 to 30 feet (3 to 9 m). Between this surficial sandy layer and limestone bedrock exist alternating layers of undifferentiated clayey sands, sandy clays, and clays. These units attain a maximum thickness of about 120 feet (37 m), but the average thickness of these sand and clay units throughout the study area is about 50 feet (15 m). The wide range in thickness is primarily due to the irregular surface of the limestone bedrock and to some extent the undulating surface topography. (Erosion and solution are responsible for the undulating nature of the bedrock surface.) Cross-sections constructed from well logs and monitoring data illustrate the generalized contact surfaces between the limestone bedrock and the overlying unconsolidated deposits (Figure 4). The locations of the cross-sections are shown in Figure 5.

The unconsolidated deposits elsewhere in Hillsborough County normally comprise a surficial aquifer. Generally, this surficial aquifer is separated from the lower Floridan Aquifer by relatively impermeable sandy clay and clay layers. However, the surficial aquifer normally found above the Floridan Aquifer is missing or discontinuous in the vicinity of the Taylor Road Landfill.

The sandy clay and clay layers in the area of the landfill, where present, have low permeabilities (4.5×10^{-8} to 1.1×10^{-10} ft/sec) (1.4×10^{-6} to 3.5×10^{-9} cm/sec) (Ecology and Environment, Inc. 1980). However, areas are present near the site that have sufficient hydraulic conductivity to allow water to move directly into the upper bedrock unit of the Floridan Aquifer. Lineament studies, conducted in the vicinity of the Taylor Road Landfill, help explain the hydraulic communication. The lineaments in this area of Hillsborough

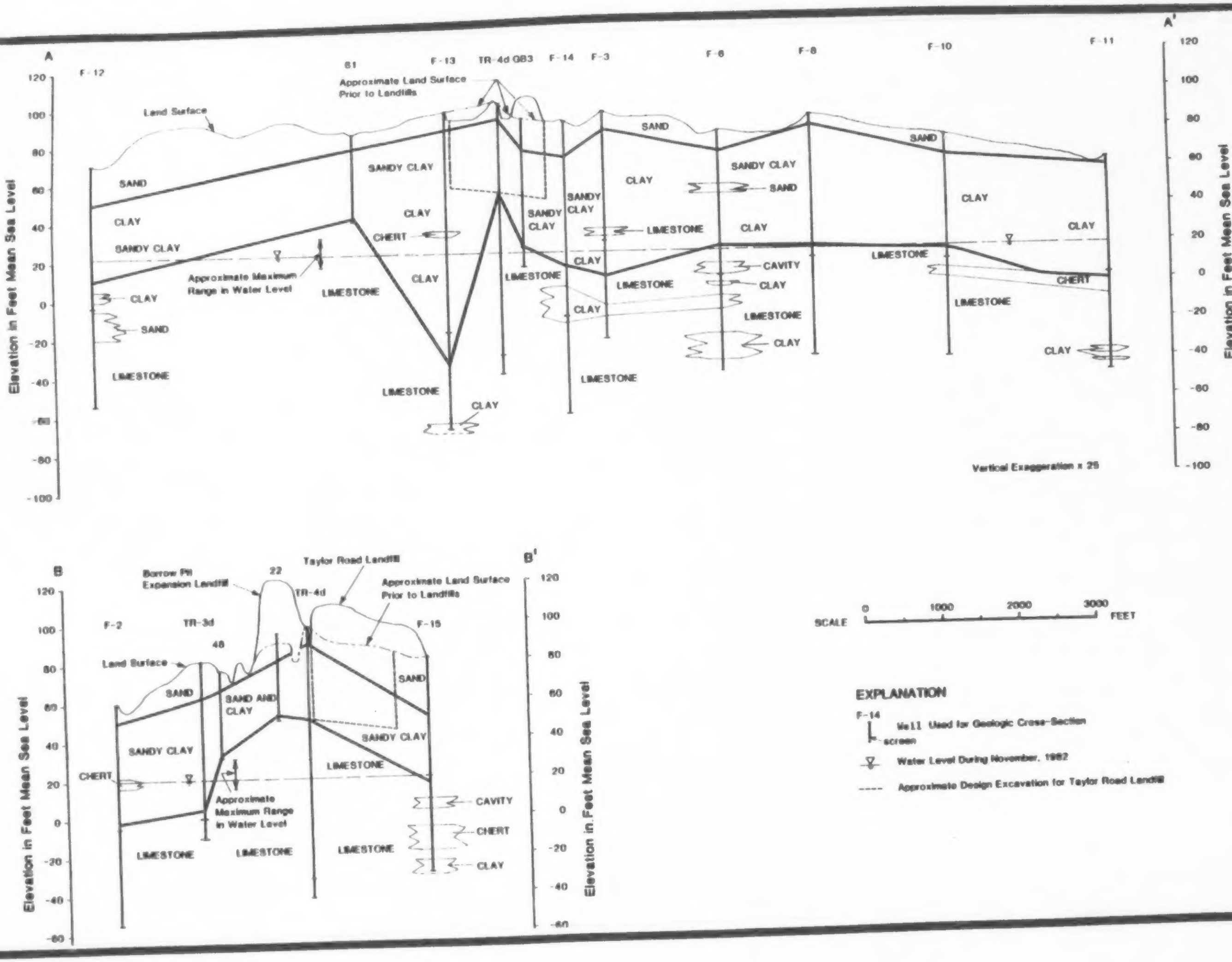
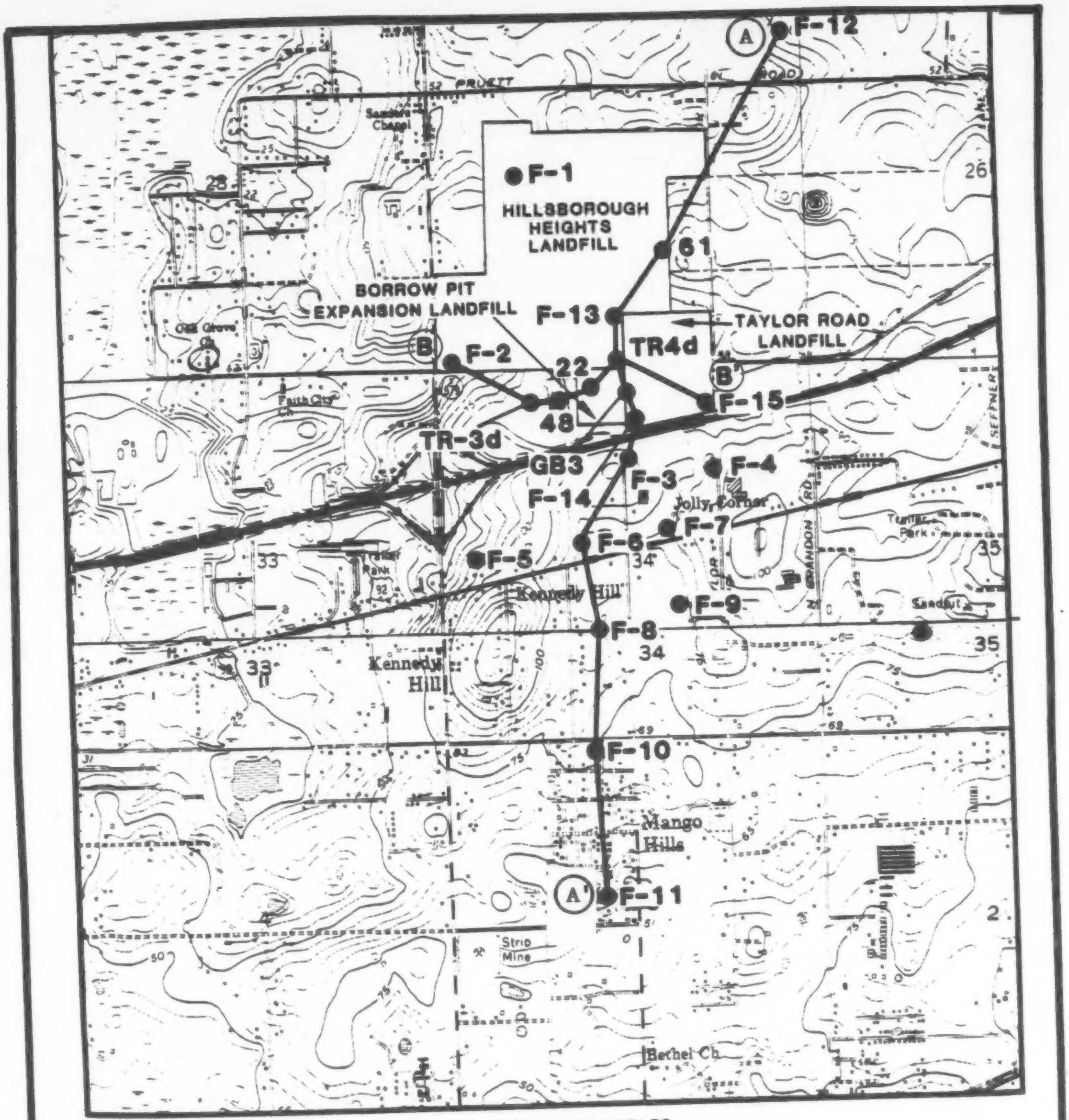

A
A'
B
B'
F-12
61
F-13
TR-4d GB3
F-14
F-3
F-6
F-8
F-10
F-11
Approximate Land Surface Prior to Landfills
Land Surface
SAND
CLAY
SANDY CLAY
CHERT
LIMESTONE
CAVITY
Approximate Maximum Range in Water Level
Elevation in Feet Mean Sea Level
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
Vertical Exaggeration x 25
F-2
TR-3d
48
22
TR-4d
F-15
Borrow Pit Expansion Landfill
Taylor Road Landfill
SAND AND CLAY
SCALE
0
1000
2000
3000
FEET
EXPLANATION
F-14
Well Used for Geologic Cross-Section
screen
Water Level During November, 1982
Approximate Design Excavation for Taylor Road Landfill

Figure 4. Generalized Geologic Cross Section (Line of Section Shown on Figure 5)

Source: Engineering Science 1983

Fig 4



BASE FROM U.S. GEOLOGICAL SURVEY 1:24,000 GUADRANGLES

0 1 MILE

EXPLANATION

A———A' LINE OF GEOLOGIC SECTION SHOWN ON FIGURE 2.2

TR-3d/GB3/F-3 ● Location and identification numbers of monitoring wells.

Figure 5. Location of Geologic Cross-Section

Source: Engineering Science 1983

County are thought to be surficial expressions of solution-enlarged joints and fractures in the limestone bedrock (Geraghty and Miller 1981). These enlarged fractures and joints may have resulted in sinks that breached the basal clay, thus allowing hydraulic communication between the two aquifers.

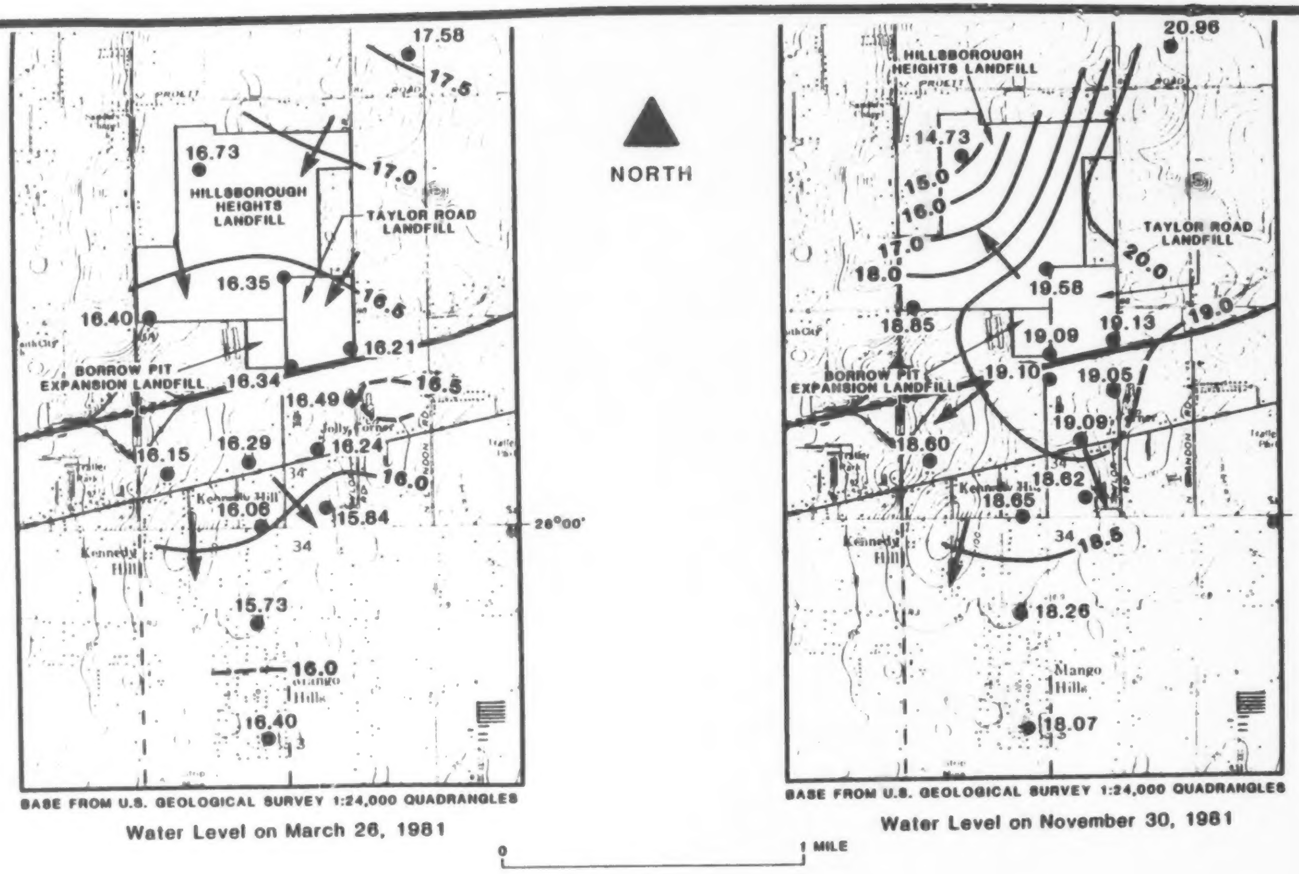
The lack of hydrologic isolation of the two aquifers in the vicinity of the Taylor Road Landfill results in the Floridan Aquifer occurring under water table conditions and in the absence of a separate surficial aquifer.

The general direction of groundwater flow in the upper unit of the Floridan Aquifer in the vicinity of Taylor Road Landfill has been variable over time. In 1980, the flow was reported to be southwest to south (Geraghty and Miller 1981). However, by March 1981 groundwater flow was shown to be in a more southerly direction. By November 1981, a hydraulic gradient had developed to the northwest. and groundwater flow from the site was radiating to the northwest, west, southwest, and south. These variations in groundwater flow directions between March 1981 and November 1982 are illustrated in Figure 6.

Water levels measured in September 1983 indicate that groundwater flow changed again to a southwesterly direction (Geraghty and Miller 1984). No explanation has been offered for the drastic reduction in water levels in well F-1, which is partially responsible for gradient changes. Significant groundwater withdrawals were not recorded from the Hillsborough Heights Landfill and other explanations have not been presented. The groundwater flow direction in the Floridan Aquifer in the vicinity of the Taylor Road Landfill has returned to its typical south and southwesterly direction since the 1981 flow anamoly was recorded in March 1981.

WASTE DISPOSAL HISTORY

The Taylor Road Landfill was originally constructed in the mid-1950's as a borrow pit on property owned by the Florida DOT. Aerial photos from 1960 show an access road into the site at a rest area on Interstate 4 on the southern border of the Borrow Pit Expansion site. Supposedly, this road provided ready access from a main thoroughfare into the Borrow Pit Expansion site, as well as onto the western side of the Taylor Road Landfill site. Before the County purchased the property, an undetermined and undocumented amount of illegal dumping occurred at the Taylor Road Landfill.



EXPLANATION

—16.0— WATER TABLE CONTOUR. CONTOUR INTERVAL ONE FOOT WITH SUPPLEMENTAL ONE-HALF FOOT CONTOURS. DATUM IS MEAN SEA LEVEL. DASHED WHERE APPROXIMATELY LOCATED.

16.34 ● CONTROL WELL AND WATER-TABLE ALTITUDE.

→ DIRECTION OF GROUND-WATER FLOW.

Figure 6. Water Table and Direction of Groundwater Flow in Upper Limestone Bedrock

Source: Engineering Science 1983

(continued)

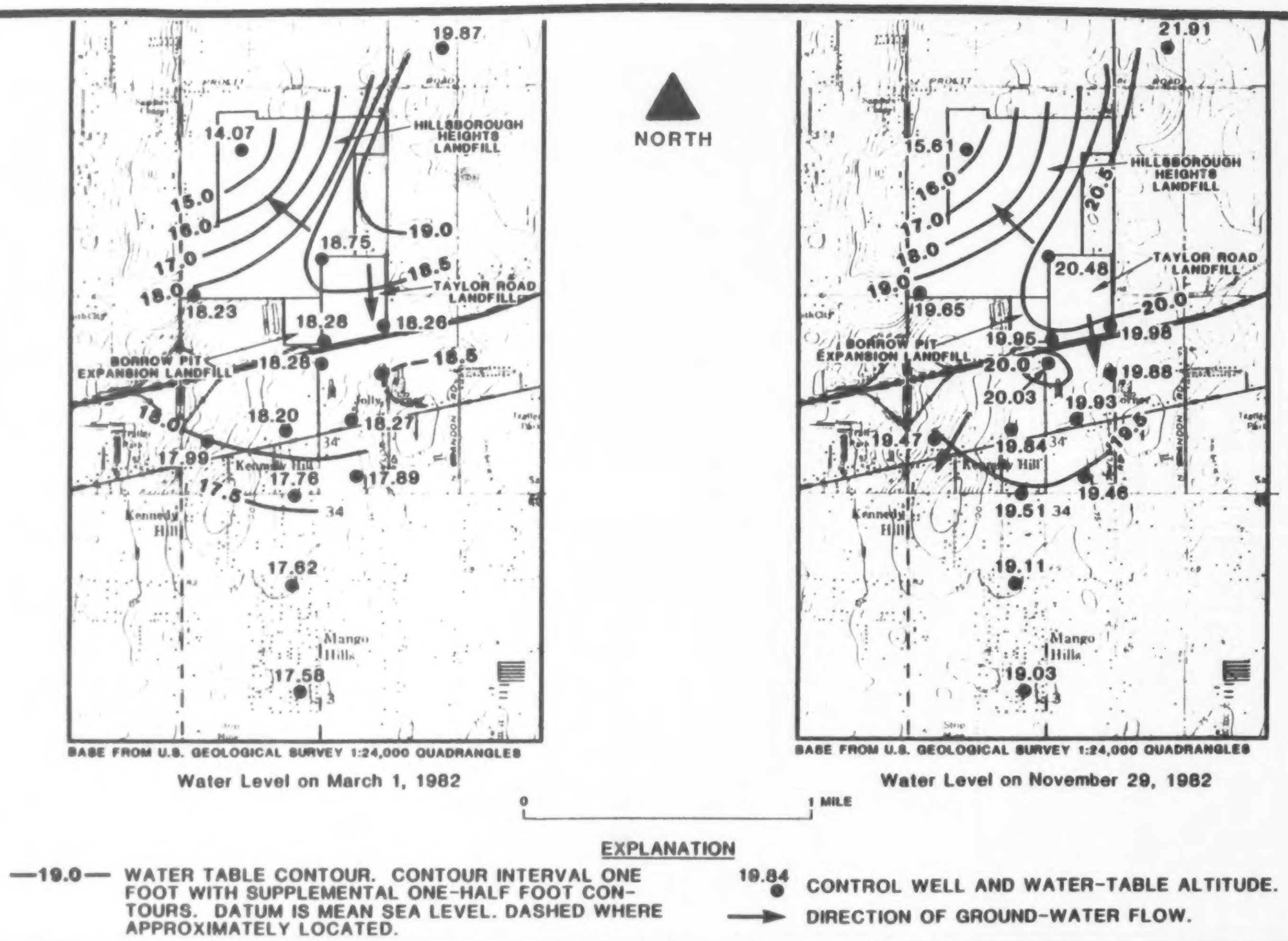

19.87
14.07
HILLSBOROUGH HEIGHTS LANDFILL
15.0
16.0
17.0
18.0
19.0
18.75
18.5
TAYLOR ROAD LANDFILL
18.23
18.28
18.26
BORROW PIT EXPANSION LANDFILL
18.28
18.5
18.20
18.27
17.99
17.76
17.89
17.5
Kennedy Hill
17.62
Mango Hills
17.58
BASE FROM U.S. GEOLOGICAL SURVEY 1:24,000 QUADRANGLES
Water Level on March 1, 1982
NORTH
21.91
15.61
HILLSBOROUGH HEIGHTS LANDFILL
20.5
16.0
17.0
18.0
19.0
20.48
TAYLOR ROAD LANDFILL
19.65
20.0
19.95
19.98
BORROW PIT EXPANSION LANDFILL
20.0
19.88
20.03
19.93
19.47
19.84
19.5
19.46
19.51
Kennedy Hill
19.11
Mango Hills
19.03
BASE FROM U.S. GEOLOGICAL SURVEY 1:24,000 QUADRANGLES
Water Level on November 29, 1982
0
1 MILE
EXPLANATION
—19.0— WATER TABLE CONTOUR. CONTOUR INTERVAL ONE FOOT WITH SUPPLEMENTAL ONE-HALF FOOT CONTOURS. DATUM IS MEAN SEA LEVEL. DASHED WHERE APPROXIMATELY LOCATED.
19.84 ● CONTROL WELL AND WATER-TABLE ALTITUDE.
→ DIRECTION OF GROUND-WATER FLOW.

Figure 6. (continued)

Source: Engineering Science 1983

On May 15, 1976, Hillsborough County was issued a permit to operate a sanitary trench landfill in the abandoned DOT borrow pit. Later studies (Engineering Science 1981) defined the base of the area at a range of 25-35 feet (8-11 m) below the natural grade. During its active life, the site received up to 800 tons (726 metric tons) per day of municipal solid waste for burial in the trench's cells. Operations proceeded as follows: after entering the disposal area by means of a gravel access road, refuse trucks passed a landfill office and were directed to the site's disposal or discharge area. The trucks discharged their contents and exited the area by way of the same gravel road. Heavy equipment was used to compact the discharged refuse, which was covered with 6 inches (15 cm) of soil material at the end of the day. The site was open six days a week and accepted refuse from the metropolitan Tampa area.

On December 21, 1978, the County applied for reissuance of their operating permit that was expected to expire February 1, 1979 and an extension was granted. After the site was filled and contamination was found, it was officially closed in February 1980.

While the landfill was active, the following wastes were reported as having been deposited there (DSW 1977; USEPA 1980b; USEPA 1980c):

septic tank waste
grease trap waste
chlorine solutions
fungicides
solvents
halogenated organics
insecticides
herbicides
salts
poisons
oils
sludges
alcohols
paint
paint thinner

The quantities of these wastes deposited at the Taylor Road Landfill were not documented, and therefore are unknown.

While the Taylor Road Landfill site was open, the County was cited for violating the following local and state regulations:

- Lack of an all-weather access road
- Disposal of garbage in contact with water
- Ponding of water over completed cells
- Surface water runoff moving off-site
- Leachate found off-site
- Lack of adequate fencing to limit access
- Lack of daily cover on working face of cell
- Lack of proper groundwater monitoring
- Depositing solid waste within 1000 feet (305 m) of residence served by a shallow aquifer providing potable water
- Uneffective gas control.

The Borrow Pit Expansion site was constructed under DER direction with a 5-foot (2 m) clay liner and an underdrain leachate collection system. A weigh station was set up where refuse vehicles were required to stop and have their wastes identified and recorded. The site received approximately 1200 tons per day (1089 metric tons/day) of solid waste. It remained open for 6 months, from February to October 1980.

DESCRIPTION OF CONTAMINATION

The initial investigations of suspected groundwater contamination from the Taylor Road Landfill completed in 1979 by EPA Region IV's Surveillance and Analysis Division (SAD) showed significant levels of low-molecular-weight organic compounds in sampled wells. The locations of the sampled wells are shown in Figure 7.

300.65(a)(2)
contamination
of drinking
water supply

A total of 14 organic compounds were identified (Table 1). Because EPA determined that the levels of trichloroethylene, 8.3 to 11 ppb (ug/l), posed a potential health risk for chronic exposure to people, owners of the wells were advised to stop using the water for consumptive purposes.

300.65(a)(i)(A)
population at
risk

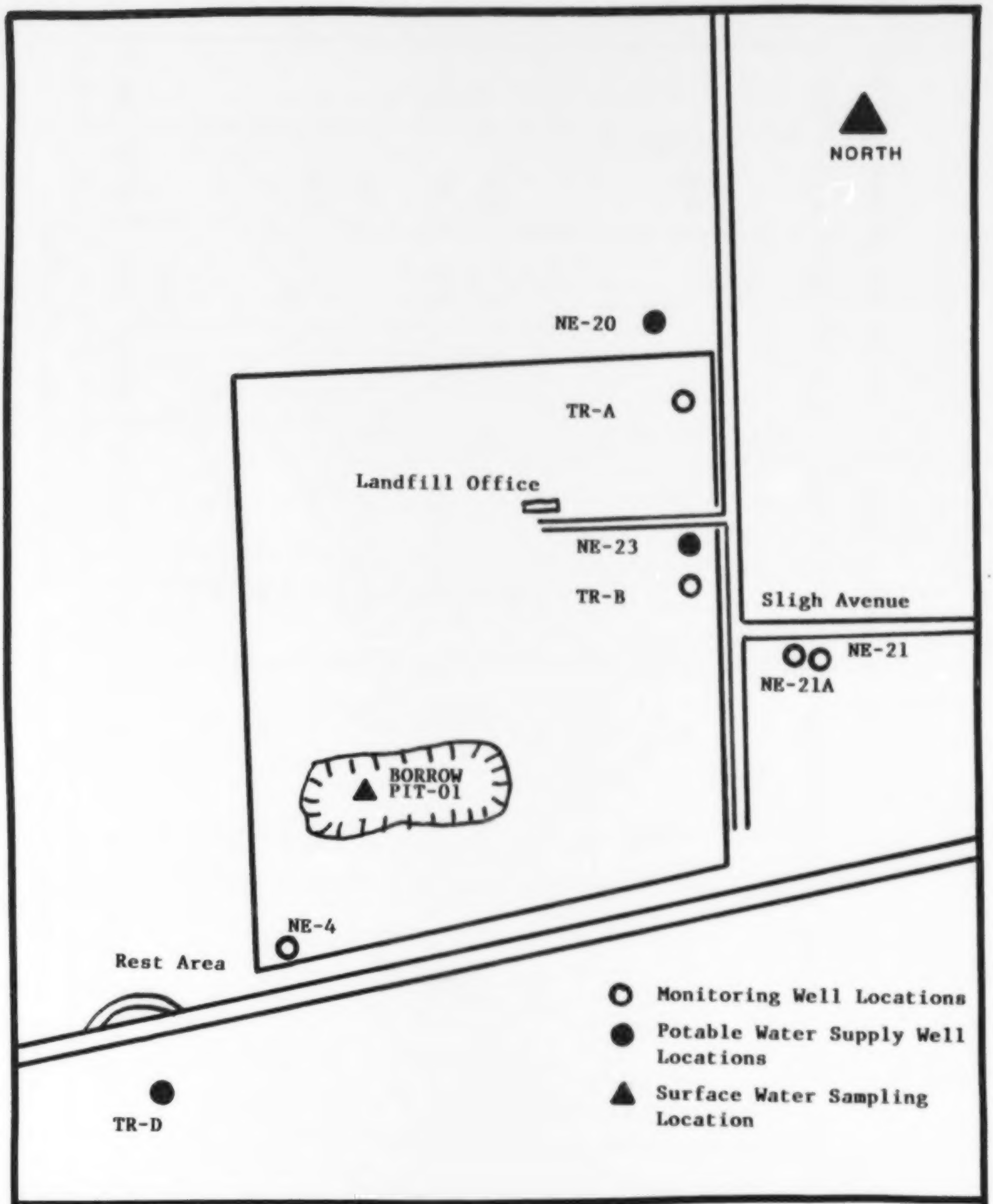

NORTH
NE-20
TR-A
Landfill Office
NE-23
TR-B
Sligh Avenue
NE-21
NE-21A
BORROW PIT-01
NE-4
Rest Area
TR-D
○ Monitoring Well Locations
● Potable Water Supply Well Locations
▲ Surface Water Sampling Location

Figure 7. Initial Taylor Road Landfill Sampling Locations

Source: USEPA 1980a

TABLE 1. TAYLOR ROAD LANDFILL VOLATILE ORGANICS, OCTOBER 30-31, 1979 (ug/1;ppb)

PARAMETER	PIT-01	NE-20*	TR-A	NE-23*	TR-B	NE-21A*	NE-21	NE-4	TR-D8	TR-E*
dichlorodifluoromethane			6.4		7.5			T<5		
methyl chloride					T<5					
vinyl chloride		T<5	14	T<5	18		T<5			
chloroethane		T<5	T<5		6.1		T<5			
methylene chloride		22	55	8.0	220		9.9			
trichlorofluoromethane	27	T<5	T<5		T<5		T<5	14		
1,1-dichloroethylene		24	6.4	5.3	29	T<5	8.2		8.9	
1,1-dichloroethane		57	68	50	140	13	47		11	
1,2-trans-dichloroethylene		11	70	23	120	T<5	14		T<5	
chloroform		T<5								
1,2-dichloroethane					T<5					
1,1,1-trichloroethane		43	T<5	T<5	62	T<5	10	T<5	12	T<5
1,2-dichloropropane				T<5	T<5					
trichloroethylene		10	20	10	53		11		8.3	
benzene					20					
tretrachloroethylene		17	14	8.7	32		8.6			
toluene					13					
chlorobenzene					T<5					
ethylbenzene					7.6					
dichlorobenzene			T<5							
chlorofluoromethane			13	T<5	20					
dichlorofluoromethane		15	50	20	52	T<5	16		T<5	
carbon disulfide								30		
tetrahydrofuran					2,100			T<5		
acetone										
Depth of well in feet		U**	64.5	200	67.5	90	U**	79	U**	173

*Potable water supply wells
**Unknown
T-Trace

Source: USEPA, Surveillance and Analysis Division, 1979

In December 1979, EPA notified the County that contamination had been detected in the water supply wells around Taylor Road Landfill. These actions prompted the County to hire a consulting firm to conduct a groundwater investigation. This investigation was intended to provide additional information on the extent and the flow direction of contamination.

300.68(e)(2)(ii) extent of substance migration

300.68(e)(3)(ii) extent of present or suspected migration

The initial sampling and analysis by County consultants (Geraghty and Miller 1980) confirmed EPA's initial finding that residential wells were contaminated and that the probable source was the Taylor Road Landfill. Another major conclusion from this investigation was that adequate geologic and hydrologic information was not available and that additional investigations would be necessary before accurate delineation of the contamination could be accomplished.

300.66(c)(2)(iii) assessing migration potential

In July of 1980, Hillsborough County retained the same groundwater consulting firm to further investigate the problem and, if possible, to develop appropriate remedies. In a meeting between the EPA, Hillsborough County and the consultants, a three-part program was agreed upon. This program included:

300.64(a)(1) evaluation of hazard

- Establishing the horizontal and the vertical extent of the contamination within the Floridan Aquifer. This was to be initiated by the sampling of 52 wells within and adjacent to the landfill.

300.68(e)(3)(ii) extent of present or expected migration

- Beginning a program for the delivery of bottled water to area residents within a specified radial distance from the landfill.

300.65(b)(2) alternate water supplies

- Beginning the design and construction of County water lines to be connected to all residences within a given radius of the Taylor Road Landfill.

In February 1981, the findings of the County's groundwater investigation were reported:

- Five volatile organic compounds were consistently present in groundwater samples collected within and near the landfill.

300.65(a)(2) contamination of drinking water supply

- Calcium was the main inorganic contaminant in the monitored wells.

- The area of volatile organic contaminant influence inferred from laboratory analysis of water samples collected in December 1980 was smaller than the area observed in late 1979 and early 1980.

300.68(e)(2)(ii) extent of substance migration

- Contamination was not indicated in the lower unit of the Floridan Aquifer.
- The change in the area of contamination was related to groundwater flow conditions. Some of this effect was attributed to the capping of Taylor Road Landfill during closure operations.
- Volatile organic contaminants were moving in pulses appearing to be related to the summer rainy season and the subsequent rises in the Floridan Aquifer potentiometric levels.
- The Taylor Road Landfill was the source of the contamination.

The recommendations from this investigation included:

- Continuation of the monitoring program and installation of additional monitoring wells.
- Sampling of gas from the venting system and analyses for volatile organic compounds. The gas analyses should be compared to leachate and groundwater quality analyses to attempt to determine if biodegradation of some of the volatile organic constituents had taken place.

Also during 1980 and 1981, the County hired a firm to assess the potential health effects from consuming water from the contaminated wells. This report concluded that, despite the presence of some compounds requiring further analysis, the toxicologic data indicated that no long-term health hazards existed from exposure to these compounds at the levels reported (Toxicology and Pharmacology, Inc. 1981). This conclusion was based partially on the assumption that the contaminant levels were decreasing. However, the report recommended continued monitoring for the parameters in question.

300.68(e)(2)(i) extent of threat to health, welfare, or environment

In 1981, the EPA requested that its ECAO evaluate the potential health hazards associated with the consumption of water from the contaminated wells. This report indicated that a health hazard did exist and that long-term exposure could be deleterious to the health of users, especially the young and the old (USEPA 1982).

In September 1981, EPA's Field Investigation Team investigated and evaluated the Taylor Road Landfill using the Hazardous Ranking System (HRS). The site received an overall score of 42.4, which resulted in its placement on the National Priority List (NPL) (Ecology and Environment, Inc. 1980).

300.64(a)
preliminary
assessment

In November 1981, another technical consultant was contracted by EPA to further investigate mechanisms by which leachate was being generated at the Taylor Road Landfill. This study was initiated to describe the extent of groundwater contamination and to provide EPA with an evaluation of alternative remedial measures for eliminating the exposure of nearby water supply wells to the leachate.

300.68(f)
remedial
investigation

300.68(g)
development of
alternatives

The Remedial Investigation/Feasibility Study (RI/FS) began with a geophysical investigation designed to aid in the identification of the base of the landfill. Although the results of this study were not conclusive, the study did provide useful information concerning the interface between the unconsolidated material and the underlying bedrock.

In October 1982, a second part of this study was initiated to evaluate the effectiveness of the landfill cover. Results showed that annual percolation through the landfill cover would increase as yearly rainfall increased above normal conditions. Annual percolation through the cover for a simulated annual rainfall of 74.2 inches (188 cm) was approximately 12 million gallons (4.54×10^{7} l). Annual rainfall greater than 75 inches (190 cm) was shown to occur once every 5 years. This quantity of water would contribute significantly to the quantity of leachate originating from the landfill. It was also shown that significant quantities of runoff from the landfill percolated to the water table along drainageways around the landfill, further adding to the leachate generation.

300.68(a)
assessment for
further action

Throughout the period from 1981 to 1982, the County had been monitoring selected wells. This program was designed to evaluate contaminant levels and to detect any increase in the size of the plume. These data were used to construct plots indicating the areal extent of the contamination. The plots, presented in Figure 8, show the plume movement from December 1980 to February 1983. Analysis indicated that the transport rate of volatile organic compounds is on the order of several hundred feet per month at the landfill.

300.68(e)(1)
extent of threat
to health, welfare
or environment

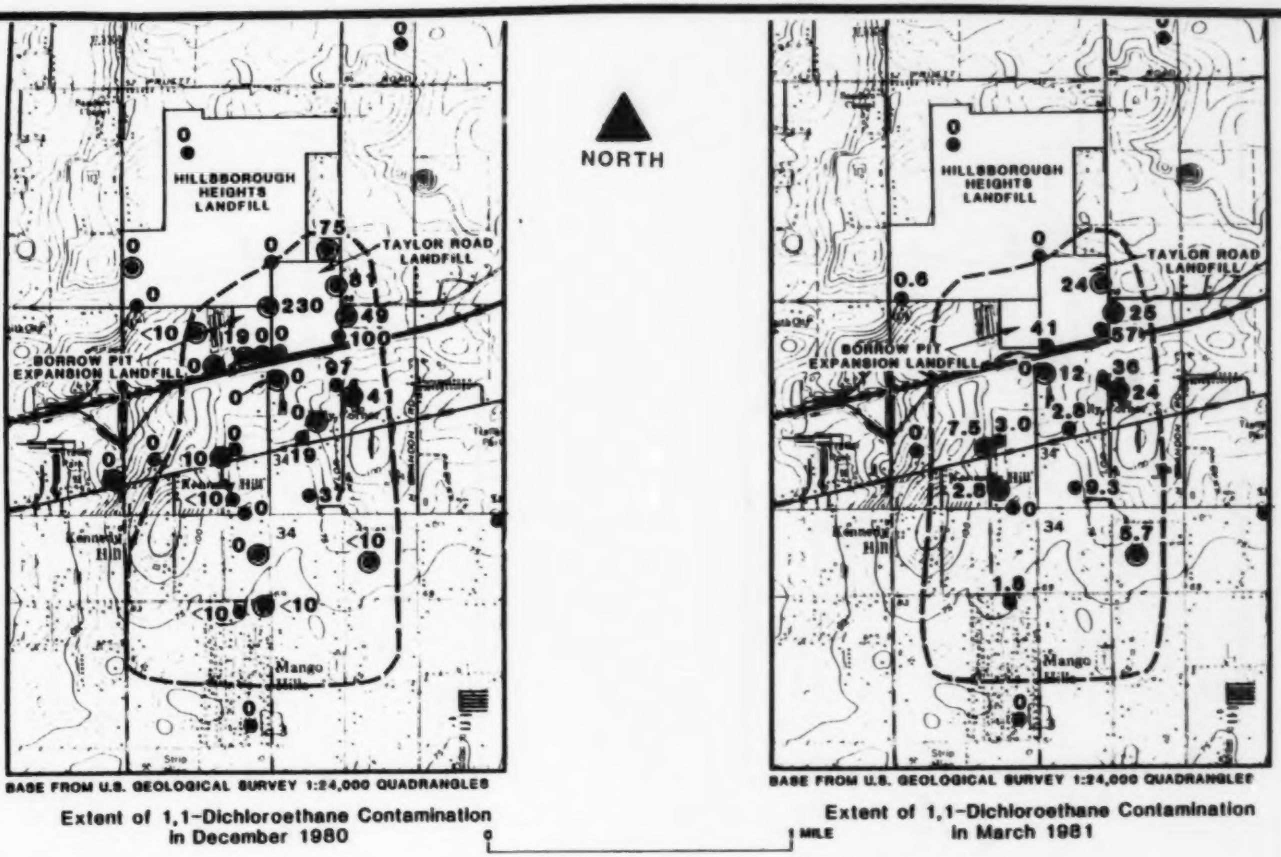
In 1980, it was also discovered that methane gas was migrating from the site and was presenting health and environmental problems. Evaluations of the site indicated that gas was migrating primarily to the east under Taylor Road. Evidence of this movement were the large quantities of gas noted at test holes located only short distances off-site along the interstate right-of-way to the south and to the north on privately owned property (DER 1980). This indicated that the gas control system installed during closure of the site was not functioning properly and that methane had also become a serious environmental problem.

In November 1983, complaints from area residents about oil and grease contamination in their wells prompted the County to authorize and fund a special groundwater study. The contamination was reported to be in wells north and west of the Taylor Road Landfill and the other landfills in the area. Results from the study indicated that the landfills in the area were probably not the cause of the oil and grease contamination. Speculations were made, but no documented evidence was given to indicate the source of contamination.

PLANNING THE SITE RESPONSE

Initiation of Site Response

In December 1978, as the Taylor Road Landfill began to reach its capacity, the County proposed to expand the site to include an adjacent area of 220 acres (89 ha). Local groups opposed to the expansion expressed their concerns in writing to the regional EPA office. They claimed that area drinking water supplies might already be contaminated due to the contents of and the practices at the existing site which attracted rats and flies and created health problems.



BASE FROM U.S. GEOLOGICAL SURVEY 1:24,000 QUADRANGLES

Extent of 1,1-Dichloroethane Contamination in December 1980

BASE FROM U.S. GEOLOGICAL SURVEY 1:24,000 QUADRANGLES

Extent of 1,1-Dichloroethane Contamination in March 1981

EXPLANATION

--- LINE OF EQUAL CONCENTRATION OF 1 PPB. APPROXIMATELY LOCATED.

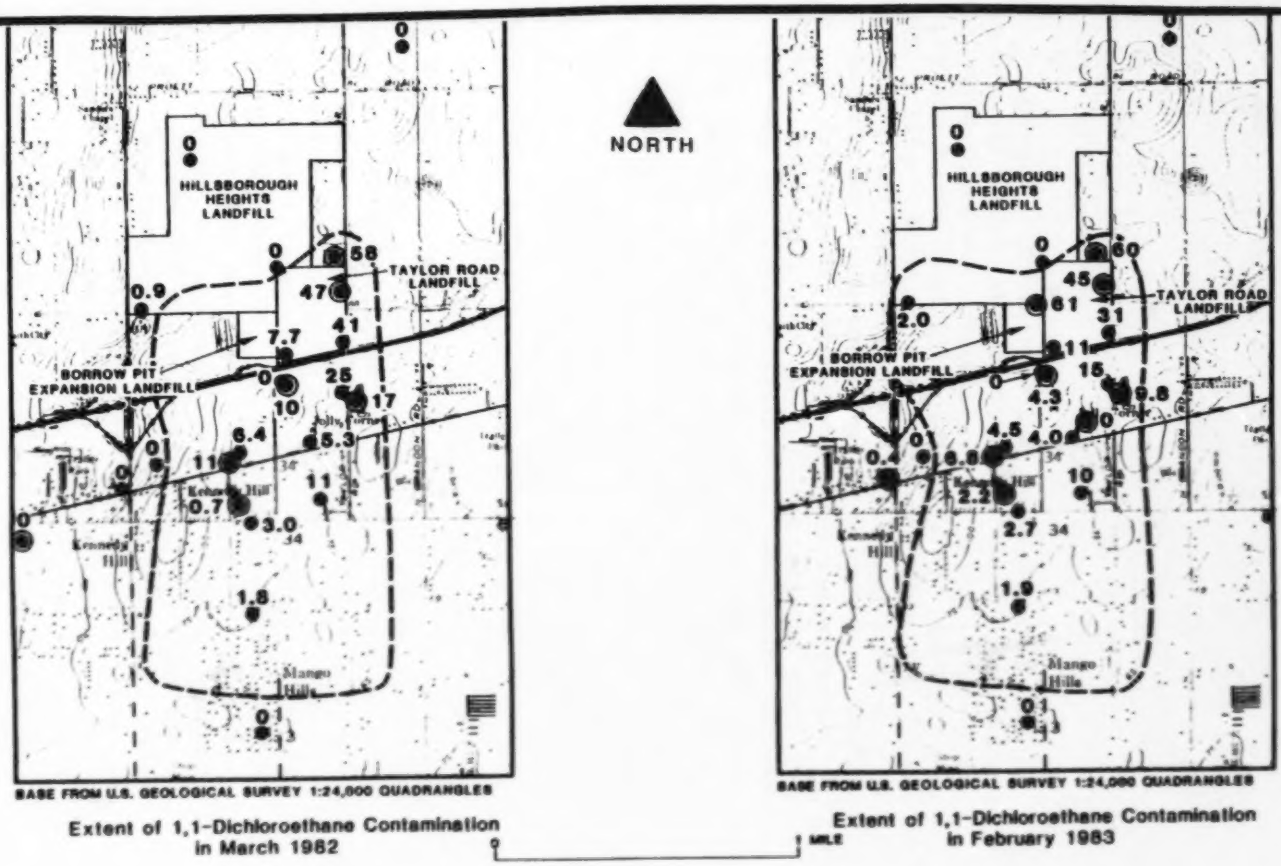
19● GERAGTHY AND MILLER MONITORING WELL AND CONCENTRATION OF 1,1-DICHLOROETHANE IN WATER IN PPB.

37◉ OTHER WELL AND CONCENTRATION OF 1,1-DICHLOROETHANE IN WATER IN PPB.

Figure 8. Plume Management from December 1980 to February 1983

Source: Engineering Science 1983

(Continued)



Extent of 1,1-Dichloroethane Contamination in March 1982

Extent of 1,1-Dichloroethane Contamination in February 1983

EXPLANATION

- – – – LINE OF EQUAL CONCENTRATION OF 1 PPB. APPROXIMATELY LOCATED.
- 19● GERAGTHY AND MILLER MONITORING WELL AND CONCENTRATION OF 1,1-DICHLOROETHANE IN WATER IN PPB.
- 37◉ OTHER WELL AND CONCENTRATION OF 1,1-DICHLOROETHANE IN PPB.

Figure 8. (Continued)

Source: Engineering Science 1983

In early August 1979, EPA scheduled a site inspection trip to Taylor Road Landfill, in part because of the numerous letters they received regarding the proposed expansion, but also as part of a nationwide spot check of landfills ordered by Congress under RCRA. On August 23, 1979, representatives from EPA and the U.S. Geological Survey visited the site, but were unable to collect any samples because of equipment malfunction. A second trip was planned for the fall.

Meanwhile, EPA was invited to attend a local town meeting at which the Taylor Road Civic Association presented numerous violations of state regulations occurring at the landfill. Specifically, four problems were noted. First, they complained that the County frequently had been cited by DER during routine site inspections for inadequate landfill practices, including lack of daily cover, ponding on-site, and migration of leachate off-site. Second, it was alleged that the borrow pit had been accessible to interstate highway traffic since the pit's construction in the mid-1950's and had received wastes at times prior to 1976. Third, unconfirmed reports claiming that the landfill continued to accept hazardous substances after it commenced operations in 1976 were noted, although no official records of generators at the site could be found. Fourth and last, no hydrogeological analysis to assess the suitability of the area for use as a landfill was conducted prior to 1976, nor was a liner installed.

On October 30, 1979, EPA Region IV sent a team from the Surveillance and Analysis Division to investigate the problem and to sample groundwater at and near the site. Analysis completed in December by EPA's Water Supply Branch revealed that soil and monitoring wells were heavily contaminated with such organic compounds and carcinogens as vinyl chloride, 1,1 dichloroethylene and methylene chloride, as well as metals, including lead, barium and chromium. Also, potable wells contained traces of various volatile organic compounds (VOC's). Since VOC's are bioaccumulative, they may be harmful even when present in minute quantities; therefore, EPA had determined that there were no acceptable concentration levels for VOC's.

300.63(a)(4)
discovery

Moreover, heavy rainfall typical of Florida resulted in surface ponding which, in combination with improper management practices, design, and construction at the Taylor Road site, caused groundwater contamination and threatened the region's deep and shallow aquifers.

Emergency measures, as previously mentioned, were taken in January 1980, but a preliminary assessment of the site in March 1980 by EPA documented a still contaminated water supply, noticeable odors, and evidence of unknown amounts of solvents, solids and hospital wastes buried. An April 7, 1980 EPA Region IV Air and Hazardous Materials Division inspection noted escaping unidentified gas from standing water on-site. Tests conducted on August 20, 1980, by a team comprised of personnel from Hillsborough County and DER found methane gas off-site at concentrations exceeding the lower explosive limit, even though a preliminary gas venting system had been installed. Later that month, the DOJ drew up an Administrative Consent Order in which the County would accept full liability and responsibility, financial and otherwise, for all further necessary corrective action. The County refused to sign and, in October 1980, the suit was filed by EPA requiring the County to clean up the landfill, restore the aquifer, eliminate future soil or groundwater contamination, and conduct a study of the effects of contamination on the food chain in Tampa.

300.64(a)
preliminary
assessment

300.68(c)
administrative/
judicial process

In May 1983, the County hired gas control experts to evaluate the existing ventilation system and, if necessary, design new gas control plans. Final plans were approved in December 1983 at about the same time the County contracted with other consultants to design improvements in the cap, cover, and drainage systems.

Selection of Response Technology

A remedial alternatives investigation was begun by a contractor under the direction of EPA in November 1981. This study was intended to confirm the presence and the extent of site contamination and to evaluate existing pollution controls (i.e., cap, drainage ditches, and gas control system). In addition, six remedial alternatives were investigated for controlling leachate generation at the landfill:

300.68(g)
development of
alternatives

- Constructing an impermeable barrier around the landfill

300.70(b)(1)(iii) (A) impermeable barriers

- Constructing a permeable treatment bed in the upper limestone bedrock south of the landfill
- Creating a hydraulic barrier around the landfill

300.70(b)(1)(iii)(c) groundwater pumping

- Isolating the solid waste from percolation water

300.70(b)(1)(ii)(A) surface seals

- Relocating the solid waste
- Constructing a subsurface drainage system around the landfill.

300.70(b)(1)(iii) (D)(1) subsurface drains

Two of these alternatives, a barrier wall and the hydraulic barrier, were intended to physically contain the leachate. The permeable treatment bed and the leachate collection system were alternatives intended to rehabilitate the Floridan Aquifer. The isolation of the solid waste from percolation was intended to reduce the quantities of leachate generated. Excavation and relocation of the solid waste was intended to remove the source of the leachate. These remedial alternatives, along with their description, rationale for rejection or acceptance, and NCP reference, are summarized in Table 2.

The selected remedial alternative was the installation of the impermeable cap and the surface drainage system. The system was selected because it was technically feasible, did not jeopardize the existing integrity of the Taylor Road Landfill or adjacent landfills, and had essentially no human health or environmental risk associated with its implementation.

In order to implement the appropriate remedial actions for the Taylor Road Landfill, EPA filed suit, and in June 1983, a consent decree was signed between EPA and Hillsborough County. The remedial alternative, suggested by EPA's contractor, was included in the consent decree. The consent agreement between the County and EPA had six basic goals:

- Upgrade the surface cap

300.70(b)(1)(ii)(A) surface seal

- Channelize surface drainage along the eastern and southern site boundaries

300.70(b)(1)(ii) (B)(2) diteches, diversions, waterways

TABLE 2. ALTERNATIVE RESPONSE TECHNOLOGIES FOR THE TAYLOR ROAD SITE

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
Impermeable Barriers[r]	The objective of this methodology is to isolate the landfill from the groundwater reservoir. A grout curtain would be placed downgradient from the landfill to create an area of groundwater stagnation at the landfill and prevent the horizontal migration of contaminants. This barrier would be completed into the limestone bedrock.	Impermeable barriers offer long-term effectiveness with minimum maintenance. However, the barrier wall technology was rejected because there is no well defined or continuous confining stratum in the limestone under the landfill to prevent downward seepage of leachate. It would be extremely difficult to provide an effective grout curtain to depths that would preclude the escape of contaminants under the curtain.	300.70(b)(1)(iii)(A)(2)
Permeable Treatment Bed[r]	The objective of this methodology is to passively treat the groundwater as it flows through the aquifer. A trench would be excavated into the limestone bedrock downgradient from the landfill, filled with the activated carbon and covered. The groundwater would be treated as it flowed through the treatment bed.	This alternative was rejected because there is no well defined or continuous confining stratum in the limestone under the landfill to prevent migration of contaminants beneath the treatment bed. The treatment bed would periodically need to be replaced.	300.70(b)(2)(ii)(C)(2) 300.70(b)(2)(ii)
Hydraulic Barrier[r]	The objective of the hydraulic barrier is to isolate the landfill from the groundwater reservoir. A line of recharge wells hydraulically upgradient from the landfill would divert groundwater flow around the landfill. A line of discharge wells downgradient from the landfill would capture leachate emanating from the landfill.	The Karst topography was responsible for the rejection of this alternative. Groundwater pumping would increase the likelihood for sinkhole development or collapse of any existing sinkholes in the vicinity of the landfill. Sinkhole collapses would compound the isolation problem at the Taylor Road Landfill and would create significant problems at the adjacent landfills. Groundwater pumped from the aquifer would need to be treated prior to injection through the recharge wells.	300.70(b)(1)(iii)(C)(2)

a - accepted
r - rejected

(continued)

TABLE 2. (CONTINUED)

RESPONSE TECHNOLOGY ALTERNATIVE	DESCRIPTION	RATIONALE FOR REJECTION/ACCEPTANCE	NCP REFERENCE
Relocation of Solid Waste[r]	Relocating the solid waste is designed to remove the source of the leachate. The wastes would be excavated to 30 or 40 feet using a backhoe or dragline. Deeper digging would require a crane with a clamshell bucket. The wastes would be loaded directly onto trucks using the excavation equipment and transported to another landfill.	Although the source of groundwater contamination would be eliminated, this alternative was also rejected. Groundwater contamination would increase during the period when the solid wastes are being removed. A landfill for accepting wastes from Taylor Road would need to be permitted and constructed. There are human health and environmental risks associated with handling the wastes.	300.70(c)
Subsurface Drainage System[a]	The objective of a subsurface drainage system is to lower the water table at the landfill and capture contaminated water. A subsurface drainage system would consist of a trench excavated into the limestone bedrock and lined at the bottom with drainage pipe in a gravel envelope. The trench would extend around the landfill. Groundwater collected in the drain would be pumped to the surface and treated.	Lowering the water table would increase the likelihood for sinkhole development and collapse of any existing sinkholes in the vicinity of the landfill (see Hydraulic Barrier Alternative). The intercepted water would need to be treated and a means for using or disposing of the water would need to be implemented. Contaminated water could escape by migrating under the drain. For these reasons, the subsurface drain system was rejected.	300.70(b)(1)(iii)(D)(1)subsurface drains
Isolation From Percolation[a]	A properly functioning landfill cover and drainage ditches would prevent percolation to the solid wastes and subsequent leachate generation. The cover would be made less permeable to reduce or eliminate percolation to the solid waste. The drainage ditches would be regraded and made less permeable to reduce or eliminate percolation to the water table and solid wastes.	A landfill cover currently is in place and would only need to be upgraded. A drainage network is also in place and would only need to be modified. The major drawback to this alternative is that the system will require constant inspection and maintenance, but it is the accepted alternative.	300.70(b)(1)(ii)(A) 300.70(b)(1)(ii)(B)(2)

a - accepted
r - rejected

Source: Engineering Science, 1983

- Install a methane gas collection and control system

- Develop long-term groundwater and methane gas monitoring programs

- Provide municipal water supplies to current residents affected by contamination

- Develop long-term maintenance programs for gas collection system, surface cap, and drainage system.

300.70(d)(2) provision of alternate water supply
300.70(b)(2)(1) gaseous emission treatment

The magnitude of these actions varied, but were intended to reduce the degree of contaminant migration off-site.

Extent of Site Response

In total, there are five cleanup goals for Taylor Road Landfill:

300.68(j) extent of remedy

- Abate soil and groundwater contamination and methane gas release caused by waste disposed of at the site

- Identify and track possible future pollution by hazardous waste or methane gas

- Secure the site by isolating the fill

- Provide proper drainage

- Eliminate the exposure of nearby potable wells from contaminated leachate from the landfill.

To achieve these objectives, the consent agreement between the County and EPA established specific remedial actions for the County to perform. However, not all of the response efforts will terminate when a desired level of pollution mitigation has been achieved. Instead, some of these efforts are indefinite in nature.

Specifically, the County was to upgrade the existing cap to pass a permeability test of 3.3 x 10^{-8} ft/sec (1 x 10^{-6} cm/sec) within 10 months of entry of the decree. The upgrading was to be accomplished by applying either 2 inches (5cm) of clayey soil at 3.3 x 10^{-8} ft/sec (1 x 10^{6} cm/sec) or 6 inches (15 cm) of loosely compacted soil with 18 inches (46 cm) of clayey soil underneath. The eastern and southern drainage ditches were to be channelized to eliminate ponding outside of the landfill's southern boundary within 90 days, and all of the ditches along the perimeter of the Taylor Road and Borrow Pit Expansion sites were also to be upgraded. Within 120 days, the ditches also had to pass a permeability test. In addition, the drainage ditch surrounding the Hillsborough Heights landfill had to be lined. Although EPA has no standards on what is an "adequate" cap or drainage ditch, these measures in combination would seem to be sufficient to achieve isolation of the contaminated fill, thus preventing percolation to the solid waste and subsequent leachate generation.

The ditches were realigned and enlarged during September and October 1983, and the Taylor Road ditches have since been lined with concrete. The clayey soil was emplaced for the ditches and cap and the cover grading was finished in May 1984. In October 1984, permeability tests were conducted on the cap material. Test results indicated that the cap met specifications. At this point, the response action was complete except for maintenance requirements.

To prevent unsafe levels of methane gas (i.e., a concentration level greater than 5 percent according to criteria established under RCRA of 1976 from migrating beyond its boundaries, the County installed a collection system, consisting of a series of 42 gas recovery wells and a flare station on-site. Due to delays in delivery of a vapor trap, the collection system was completed in August 1984; it was expected to be completed by July 1984. The monitoring program commenced in September 1984. Thirty-two methane gas monitoring wells are being tested quarterly for 30 years, and if any well shows greater than 5 percent concentration within that period, the County will initiate weekly monitoring of that well, and two adjacent wells for 2 months. In the case where the level remains at or increases above 5 percent, a new remedial gas control plan must be submitted.

A safe supply of drinking water for area residents is to be achieved by an extended public water supply. The implementation of this action was complicated by the issue of exactly who would be the recipients. The EPA ECAO's position can be summarized as wanting to use cancer risk assessment levels (where the numbers/values translate into the number of excess cancers per 100,000) as a trigger mechanism to automatically extend the water supply in the event that they detected that the plume had spread. Alternatively, the County preferred defining the area in which they had the responsibility to provide water since they would already be taking measures to remedy conditions caused by the landfill. The issue was settled with the County agreeing to supply free water to all eligible households within an area bounded by Interstate 4 to the north, the Taylor Road Landfill site to the east, State Road 579 to the west, and Clay Pit Road to the south. Quantities to be supplied are 350 gallons per day (1325 l/day) per hous--hold having up to four members. Households having more than four members will receive an additional 100 gal (378 l) per day per person. The County has until December 1984 to complete connection of the system. Service will continue so long as any person currently residing in each home remains in that residence. Thus, the response may continue indefinitely.

The termination of groundwater monitoring is also not based on contaminant reduction target levels. The consent decree sets out a period of 30 years (a duration that EPA requires for closure and post closure monitoring of all hazardous waste land disposal facilities) with quarterly and biannual testing for organics and annual testing for alkalinity, chloride, pH, specific conductance, sulfate, calcium, iron, magnesium, manganese, and sodium. All of these parameters are fixed by regular National Secondary Drinking Water Standards (under SDWA). No mention is made of a criterion to determine the extent to which the groundwater must be cleaned, although both EPA and DER have the right to seek further cleanup action for 7 years if any additional groundwater contamination is discovered.

DESIGN AND EXECUTION OF SITE RESPONSE

The site response was divided into sections based on the requirements of the consent decree. Design of the various systems were conducted by firms that specialize in these tasks.

The County retained groundwater specialists to determine the areas in the cap that required upgrading and EPA retained a contractor to ensure the work met specifications.

The consent decree mandated that about 65 percent of the surface area of the Taylor Road Landfill be upgraded within 8 months of the signing of the consent decree. Permeability tests were to be performed on an additional 6 acres (2 ha) and, if the permeability was not acceptable, these areas would also have to be upgraded. The areas requiring work were to be upgraded so that the entire surface of the site would be covered consistently with at least 2 feet (0.6 m) of clay soil with a permeability of 3.2 x 10^{-8} ft/sec (1 x 10^{-6} cm/sec) or less. An acceptable alternative standard was that the 6 inches (15 cm) have a permeability of 3.2 x 10^{-9} ft/sec (1 x 10^{-7} cm/sec) and overlie at least 18 inches (46 cm) of clayey soil.

This resulted in the County having to upgrade approximately 40 acres (16 ha) of the total 42.5 acres (17 ha) in an 8-month period. This work was to be checked and certified prior to continuation of the remedial work.

The initial step was the removal and the stock piling of top soil and subsoil. Terra Seal, a bentonite clay, was used as the soil admix. This material was blended with the subsoil, and graded and compacted over the site to meet specifications.

Once the cap had passed permeability testing, the County had 2 months to place 6 inches (15 cm) of top soil over all disturbed areas. The regrading of the site had to ensure there were no depressions that would allow surface water to collect.

The consent decree allowed 90 days for channelizing the drainage ditches just inside the eastern and southern boundaries. Within 120 days after channelizing, all ditches along the perimeter of the Taylor Road Landfill, Borrow Pit Expansion, and Hillsborough Heights Landfills had to be lined with 1.5 feet (0.5 m) of compacted clay having a permeability of 3.2 x 10^{-8} ft/sec^{-1} (1 x 10^{-6} cm/sec^{-1}) or less. This required the County to channelize at least 1,800 feet (549 m) of drainage way and clay line up to four times that amount within 7 months of signing the consent decree.

The County completed this requirement within the established timeframe, but the ditches' clay lining was being eroded by the water flowing through them. The clay lining was replaced and recompacted at least once, but eroded away again during the area's typically heavy rain storms. Finally, the County installed concrete drainage ditches to eliminate erosion and to minimize future maintenance. Also, the County installed concrete flumes along the slopes of the site to further minimize erosion from surface runoff. This system was only 90 percent complete in May 1984, but original specifications were met within the timeframe allowed by the consent decree.

Surface cap and drainage ditch repair activities were initiated simultaneously and coordinated to minimize interference with one another.

Weather interfered with the completion of work and there were no rain days provided by the consent decree. Also, excessive dry weather interfered with the permeability testing. Although delayed, the cap upgrading and drainage system were completed in May 1984.

The County was also required to install a methane gas collection and flare system, so consultants were hired to design and to supervise the construction of the system. The installed system included 42 collection wells, a header system, condensate traps, and a blower and flare station.

The gas collection wells are approximately 50 feet (15 m) deep and spaced 100-150 feet (31-46 m) apart around the Taylor Road site's perimeter. The header system connects all of the wells to the blower and flare station. Sample ports, condensate traps, and control valves are located throughout the system to allow for maintenance, control, and inspection. The collection system, wells, and header pipes were installed during the cap upgrading to avoid having to recompact the clay cap. The blower and flare station had not been installed by May 1984 and further delay was expected because the flame arrester required special manufacturing. The County will initially flare the methane gas, but intends eventually to recover and use the methane.

To ensure the initial remedial actions were performing as intended, the consent decree required detailed programs for monitoring groundwater and methane gas. These programs began in September 1983 and will continue for 30 years.

The groundwater monitoring program is designed to detect changes in the concentration or the location of contaminants. Samples will be collected quarterly from wells F-2, F-5, F-11 and TR-50, and semiannually from wells F-9, F-10, and F-12. In addition to these wells, three existing domestic supply wells or newly installed wells must also be sampled. All of the samples will be analyzed in accordance with EPA Method 601. A further annual sampling and analysis will be conducted for alkalinity, chloride, pH, specific conductance, sulfate, calcium, iron, magnesium, manganese, and sodium in accordance with 44 CFR, Part 233, Appendix IV (Complaint, USA v. Hillsborough County, 1983).

Water levels in all wells will be measured semiannually, so that a potentiometric surface map can be prepared to depict localized groundwater movement.

Flexibility built into the groundwater monitoring program allows for relocating monitoring points, but not for increasing the number of points. This provides for accurate groundwater monitoring if the flow direction changes.

The methane gas monitoring system was established around the Taylor Road, Borrow Pit Expansion, and Hillsborough Heights Landfills to detect methane gas migration beyond the fill area boundaries. This system consists of 32 wells extending from ground surface to bedrock and ranging in depth from 12 to 120 feet (4 to 37 m). Sample collection is scheduled on a quarterly basis.

Within 14 months after its signing, the consent decree required that all residences within the area bounded by Interstate 4 to the north, Clay Pit Road to the south, Taylor Road to the east, and State Road 579 to the west, be provided access to the County water supply. All installation charges must be borne by the

County and at least 350 gallons (1,325 l) per day must be provided to each residence. The County must also remove the Day's Inn water supply well from service within the 14-month period. Finally, the County must caution all future residential builders in the designated area that the use of County water is required.

Although construction of the water supply system was not complete in May 1984, no problems are foreseen in meeting the deadline. Installation of water mains was accomplished by May 1984 and contracts for hooking up residences were to be awarded in June 1984.

The consent decree's final requirement was for the County to develop long-term maintenance programs for the gas collection system, surface cap, and surface drainage system. This program consists of scheduled inspection of the facilities and special inspection of the cap and drainage system after intensive rainfall. Repairs must be made when required.

COST AND FUNDING

Source of Funding

As required by the consent decree between the US EPA and Hillsborough County, all project costs were paid by the County.

300.68(c)
responsible
party funding

Selection of Contractors

The County engaged in a competitive contractor selection process, based upon both cost and qualifications, for all remedial construction and installation work at the Taylor Road site. Hubbard Construction Company was selected after offering the lowest bid among four firms for construction work on the cap, cover, and drainage improvement project, as well as on-site preparation for the gas collection system. All of the methane gas monitoring wells were built and installed by Diversified Drilling Company, who won the contract over two other firms. Since Azarelli Construction Company was the sole bidder for both construction of the water mains and all plumbing services necessary to hook up area residents with the municipal water supply, this company was awarded the contract.

The first consultant, Geraghty & Miller, Inc., was hired under emergency conditions. In 1979, when contamination of well water was first discovered, the County's Utilities Division Director was faced with a time constraint to select a firm for studying the problem with which EPA was already familiar. The County turned to Geraghty and Miller (G&M) because they had done some work for EPA in the past and thus could be brought on as quickly as possible. Between the discovery of the problem and implementing remedial action at the site, G&M's tasks included: performing the initial site investigation in December 1979, conducting another more intensive hydrologic study between 1980 and 1983, and designing and installing the County's initial groundwater monitoring system. Geraghty & Miller are presently performing the quarterly groundwater sampling and analyses.

On May 11, 1983, the County engaged the services of another consulting firm to design and to supervise the implementation of a new gas control plan and to perform certain system start-up and balancing tasks. Emcon, a firm who's principal is an expert in gas control, was deemed the logical choice for the job because, having designed the Hillsborough Heights Landfill, they were already very familiar with site conditions.

CH2M Hill, a consulting firm in Tampa, was chosen to design the cap and ditch modifications, to design gas monitoring wells, and to provide engineering services for both projects. Many firms answered the Request for Proposal sent out by the County Solid Waste Department under regular County and State selection procedures. CH2M Hill appeared to be the most qualified to the County's professional selection committee.

Project Cost

The total cost of the investigation and the remedial work at Taylor Road Landfill from December 1979 to July 1984 was approximately \$3.56 million. This figure includes the current \$2 million consent decree remedial program, as well as remedial costs incurred by the County before the consent decree was signed. It also incorporates all legal expenditures, amounting to \$508,000, pursuant to the 1980 suit and the 1983 consent decree. Also, the County spent $65,800 for delivery of bottled water between January 1980 and July 1981, and $160,500 for design, construction, and connection fees for utility water lines in 1981 (Table 3). These figures are based on invoices or reports collected at County offices, verbal communication with County officials, and contractor - prepared estimates for tasks not yet completed. At the time of this writing, the remedial program was still underway. Therefore, only partial expenditures or estimated costs were available for some of the tasks.

Hydrological Investigation

Between December 1979 and mid-1984, a total of $726,374 was paid to Geraghty and Miller to cover their fees and expenses for well construction, sampling, and analysis, and technical services to investigate groundwater contamination at Taylor Road Landfill. This total incorporates all of G&M's services through August 1984, including a preliminary groundwater monitoring program involving the installation of 20 wells in 1980, one deep well in 1982, and $15,000 set aside for the installation of three new wells in 1984. A final report, due to be delivered in late fall of 1984, is also included in the contract.

The initial emergency investigation, involving groundwater quality analyses of the Taylor Road area cost $20,000. Between 1980 and 1983, G&M performed a long and exhaustive (Phase I) study to estimate the areal vertical extent of contact within the Floridan Aquifer. During this study, G&M developed a groundwater monitoring program that would later serve as part of the groundwater monitoring network currently in use. The cost of designing the program and drilling and installing the monitoring wells totalled $275,617. Approximately $150,000 of this amount went for drilling expenses. Consultant and engineering fees were $105,540. As their investigation continued, G&M received $196,860 for their services in 1981 (Phase I), $17,831 of which was for the installation of a deep aquifer well, $149,722 in 1982 (Phase II), and $84,175 in the last year (Phase IV) of their contract. A detailed breakdown is shown in Table 4.

TABLE 3. SUMMARY OF PROJECT COSTS - TAYLOR ROAD LANDFILL, SEFFNER, FLORIDA

Task	Quantity	Estimate	Actual Expenditure	Unit Cost	Period of Performance
I. CAPITAL AND R&D					
A. Hydrological* Investigation	--	--	$ 726,374.00*	--	12/79-1984
B. Cap, Cover and Drainage Improvement	--	$769,593.14	$ 772,560.14	--	
1. Construction	--	$732,999.50	($ 735,961.75)	--	2/15/84-6/1/84
2. Design	--		($ 36,598.64)	--	1983
C. Methane Gas Monitoring			$ 125,254.00		
1. Installation	32, 2" wells	$ 85,946.00	($ 85,954.00)	--	2/22/84-4/7/84
2. Design	--		($ 39,300.00)	--	1983
D. Gas Collection			$ 282,118.50		
1. Installation	42 wells	$223,338.50	($ 221,118.50)	--	2/29/84-7/84
2. Design	--	--	($ 61,000.00)	--	1983
E. Alternate Water		$824,545.00	N/A		
1. Construction	8" Mains	($421,183.75)	N/A	N/A	5/84
2. Plumbing and Hook-up	550 Households	($402,861.25)	N/A	N/A	N/A
F. Other			$ 734,300.00		
1. Legal Expenses			($ 508,000.00)	N/A	1980-1984
2. Delivery of Bottled Water			($ 65,800.00)	N/A	1980
3. Water line construction and Hook-up			($ 160,500.00)	N/A	1981
		Total	$3,465,151.64		
II. OPERATION AND MAINTENANCE					
G. 1. Gas Monitoring	--	($ 500.00/year)	--	--	--
2. Water Service	--	($60,000.00/year)	--	($109.09/HH)	--
3. Groundwater Monitoring	--	($30,000.00/year)	--	--	--
	Total	$95,500.00/year			

* Due to the current groundwater monitoring program utilizing wells that were installed either in 1980 or 1981, the design and construction cost for the program is incorporated into the total for the hydrological investigation.

SOURCE: Hillsborough County, DSW 1984

TABLE 4. HYDROLOGICAL INVESTIGATION AT TAYLOR ROAD LANDFILL, SEFFNER FLORIDA

1.	Initial Investigation	$ 20,000.00
2.	Phase I - Intensive Hydrologic Study	$275,617.00
	a. Drilling ($149,463.00)	
	b. Lab Fees ($ 20,614.00)	
	c. Engineering Services ($105,540.00)	
3.	Phase II - Study	$196,860.00
	a. Drilling deep well ($17,831.00)	
	b. Lab Fees ($104,829.00)	
	c. Engineering Services ($74,200.00)	
4.	Phase III - Study	$149,722.00
	a. Lab Fees ($93,422.00)	
	b. Engineering Services ($56,300.00)	
5.	Phase IV - Study	$ 84,175.00
	a. Drilling ($20,500.00)	
	b. Lab Fees ($14,275.00)	
	c. Engineering Services ($49,400.00)	
	Total	$726,374.00

Source: Geraghty and Miller, Inc. 1984.

TABLE 5. CAP, COVER AND DRAINAGE IMPROVEMENT, TAYLOR ROAD LANDFILL, SEFFNER, FLORIDA

A. Construction	
1. Mobilization	$ 58,000.00
2. Stripping (13,256 cv at $1.75/c.y.)	$ 23,198.00
3. Regular Excavation (11,050 cy at $180/cy)	$ 19,890.00
4. Borrow Excavation (24,078 cy at $5.75/cy)	$138,448.50
5. Garbage Disposal	$ 62,762.00
6. Soil-Clay Admix (20.7 ac)	$219,420.00
7. 12" BCCMP 190 (1f at $20.00/1f)	$ 3,800.00
8. 18" RCP(60 (1f at $25.00/1f)	$ 1,500.00
9. 30" RCP (290 1f at $35.00/1f)	$ 10,150.00
10. 12" MES (3 at $250.00 each)	$ 750.00
11. Concrete Headwalls ($3,166.37 each)	$ 9,500.00
12. Concrete Encasement (21 cy at $200.00 cy)	$ 4,200.00
13. Energy Dissipaters ($5,000 each)	$ 15,000.00
14. 4" Concrete Ditch Pavement	$ 58,050.00
15. Concrete Rubber (300 sy $50.00 sv)	$ 15,000.00
16. Grassing (123,50 sy at $.17 sy)	$ 20,995.00
17. Sodding (7,600 sy at $1.25 sy)	$ 9,500.00
18. Slag Road Surfacing (250 sy at $4.00 sy)	$ 1,000.00
19. Additional Fill (7,108 cy at $5.75)	$ 40,871.00
20. Additional Terra Seal (70,220 sf at $.25)	$ 16,677.25
21. Additional Stripping (2.58 ac at $1500.00)	$ 3.870.00
22. Additional Grassing (2.58 ac at $1310.00)	$ 3,380.00
Subtotal	$735,961.75
B. Design	$ 36,598.64
Total	$772,560.14

Source: Hubbard Construction Company 1984

Cap, Cover, and Drainage Project

Total cost of the cap, cover, and drainage ditch improvement project was about $772,000. This included additional portions of the cap and cover, which after soil auger testing by Engineering-Science contracted out by CH2M Hill), were determined to need upgrading, as well as supplies and labor needed to implement a late decision by the County to line the ditches with concrete. A detailed cost breakdown is presented in Table 5. The major components of this project were $219,420 to admix soil-clay for the cap, $139,448.50 to excavate the borrow pit, and $58,050 to line 3225 linear feet of the west and east perimeter ditches with 4 inches (10.1 cm) of concrete.

Operating and Maintenance cost estimates will not be available until the fall of 1984.

Methane Gas Monitoring

The total cost of the gas monitoring project was $125,254 (see Table 6). This included $86,000 to construct, drill, and install 32 wells and $39,300 to design and to inspect the system. The largest components of the well construction were $22,680 for drilling 8-inch (20.2 cm) bore holes, $22,680 for casing withdrawal, $11,520 for mobilization and clean-up and $8,220 for 548 cubic feet (15 m^3) of gravel. Each well required a locking cap at a unit cost of $150 or $4,800. County officials estimated that Operating and Maintenance costs would be low, at an average of $500/year spread out over 30 years. The system will be monitored by County employees.

Gas Collection

As noted in Table 7, the total cost for construction and installation of the gas collection system at Taylor Road Landfill was about $221,000. The project involved purchasing 42 recovery wells at $1,300 a piece (or $54,600 in total); 5460 linear feet of PVC piping at an average unit cost of $8.33/1f or a total of $45,467.50; 27 condensate traps at $966.67 each; a blower station at $35,388 and a flare station for $25,318; various valves and boxes at $14,450; 2 - $350 6 in (15.2 cm) sample ports and 4 - $400 8 in (20.3 cm)

TABLE 6. METHANE GAS MONITORING AT TAYLOR ROAD LANDFILL, SEFFNER, FLORIDA

A. Construction and Installation	
1. Mobilization and Cleanup	$ 11,520.00
2. Drilling	$ 22,680.00
3. Casing Withdrawal	$ 22,680.00
4. Cement Plug and Seal	$ 2,650.00
5. Installation of PVC Pipe	$ 915.00
6. Installation of PVC Screen	$ 6,240.00
7. Gravel	$ 8,220.00
8. Bentonite Pellets	$ 2,720.00
9. Locking Caps	$ 4,800.00
10. Other	$ 3,529.00
Subtotal	$ 85,954.00
B. Design	$ 39,300.00
Total	$125,254.00

Source: Diversified Drilling Company 1984.

TABLE 7. GAS COLLECTION SYSTEM AT TAYLOR ROAD LANDFILL SEFFNER, FL

A.	1. Mobilization	$ 4,000.00
	2. Gas Collection Wells (42 at$1300.00 each)	$ 54,600.00
	3. 3" PVC Header (460 lf at$5.75/lf)	$ 2,745.00
	4. 4" PVC Header (1350 lf at $6.25/lf)	$ 8,437.50
	5. 6" PVC Header (1300 lf at $8.70/lf)	$ 11,310.00
	6. 8" PVC Header (2050 lf at $9.50/lf)	$ 19,475.00
	7. 10" PVC Header (300 lf @ 12.00/lf)	$ 3,600.00
	8. Condensate Traps (27 at$966.67 each)	$ 26,100.00
	9. Blower Station	$ 35,388.00
	10. Flare Station	$ 25,318.00
	11. 3" Gate Valves & Boxes (42 at $200.00 each)	$ 8,400.00
	12. 4" Butterfly Valves & Boxes (2 at $350.00 each)	$ 700.00
	13. 6" Butterfly Valves & Boxes (2 at $475.00 each)	$ 950.00
	14. 8" Butterfly Valves & Boxes (8 at $550.00 each)	$ 4,400.00
	15. Sample Port 6" (2 at $350.00 each)	$ 700.00
	16. Sample Port 8" (4 at $400.00 each)	$ 1,600.00
	17. Concrete Pads (13 cy at $347.69/cy)	$ 4,520.00
	18. Pressure Testing	$ 2,500.00
	19. Electrical Work	$ 2,375.00
	20. Fencing	$ 4,000.00
	Subtotal	$221,118.50
B.	Design	$ 61,000.00
	Total	$282,118.50

Source: Hubbard Construction Co. 1984.

for \$2,300; 13 cubic yards (9.9 m^3) of concrete pads at \$347.69/cy , or \$4,520; \$4,000 for peripheral fencing; and \$4,875 for electrical and pressure testing activities. The total design cost, which incorporated startup and balancing tasks performed by the consultants was \$61,000 for a total project cost of \$282,018.50.

Alternate Water Supply

At the time of this writing, total figures for this project were engineering estimates only. Construction on the main pipe lines began in May 1984 and bids were let for a plumbing service contract in June, but no hook-ups had been made yet. The County had until December 1984 to connect residents with the municipal water system according to the compliance schedule in the consent agreement.

Table 8 offers an expected total cost of \$824,545 for the project. This includes \$421,183.75 for the main lines and \$143,403 for plumbing services. Connection fees per house will be \$310 for a total cost of \$170,500. Supplying 350 gallons/day (133 l/day) to each household of four will run approximately \$60,000/year. County officials determined that a new well will have to be installed at a cost of \$30,000 to boost water pressure and to ensure a consistent water flow. No work has yet begun on the new well or pumping system, so the estimated cost is still unknown.

Groundwater Monitoring

The total cost of the groundwater monitoring program at Taylor Road Landfill is included in the cost of the hydrological investigation because no additional or current costs were incurred for this program. The consent decree required Hillsborough County to monitor 10 wells, 7 of which had previously been installed as part of a monitoring network in 1980. Out of those seven wells that constitute the present program, six wells were installed at an average cost of \$6,737.50, or \$40,425 in total. One deep monitoring well in use, installed in 1981, cost \$17,831, bringing the total construction cost to \$58,256 for the wells currently in place. The location of the three remaining wells has not been agreed upon yet, although \$15,000 has already been set aside in the Geraghty and Miller contract for

TABLE 8. ALTERNATE WATER SUPPLY AT TAYLOR ROAD LANDFILL, SEFFNER, FLORIDA

I.	CAPITAL		
A.	Construction		$421,183.75
B.	Plumbing		$143,403.00
C.	New well and pumping system		$ 30,000.00
D.	Hook-up ($310 each)		$170,500.00
E.	10% Engineering Fee		$ 59,458.25
		Total	$824,545.00
II.	OPERATION AND MAINTENANCE		-----------
		Total	$ 60,000.00

Source: Hillsborough County DSW 1984.

this purpose. Expected Operating and Maintenance costs for monitoring were estimated by County officials as $30,000/year, broken down into $20,000 for lab analyses and $10,000 for consultant services to sample and report on findings (see Table 9).

TABLE 9. GROUNDWATER MONITORING AT TAYLOR ROAD LANDFILL, SEFFNER, FLORIDA

A.	Construction	
	6 Shallow Wells	$40,425.00
	1 Deep Well	$17,831.00
	1 Proposed New Well	$15,000.00

	Total	$73,256.00*
B.	Operation and Maintenance	
	Sampling and Analysis	$20,000.00
	Consultant Fees	$10,000.00

	Subtotal	$30,000.00/year

* Already included in the total expenses for the Taylor Road Hydrological Investigation.

Source: Geraghty and Miller, Inc. 1984.

PERFORMANCE EVALUATION

In 1979, the Taylor Road Landfill, owned and operated by Hillsborough County, Florida, was suspected to be the source of groundwater contamination. When the County realized that the landfill was a potential source of contamination, it was closed and capped with a clay cover. At this time, the County initiated an investigation to determine the source and the extent of the contamination. The County also started a program to supply bottled water to residents in the area whose wells showed the presence of contamination. The investigation confirmed that the landfill was a source of the contamination and prompted the initiation of additional studies. These investigations included additional groundwater studies, geophysical investigations, toxicological investigations and methane gas studies.

In 1981, EPA filed suit against the County and in 1982 a consent decree was signed and remedial actions were initiated. These remedial actions included:

- Upgrading the surface cap
- Regrading the surface to eliminate ponding of water
- Channelizing surface drainage to reduce the amount of water infiltrating into the site
- Installing a methane monitoring and collection system
- Connecting the affected residents to a municipal water supply system
- Establishing a long-term program to evaluate and to monitor contaminant movement
- Implementing a long-term maintenance program to ensure the proper functioning of all of the systems.

The remedial actions implemented at the Taylor Road Landfill were designed to prevent surface water from infiltrating the landfill cover, coming into contact with the waste materials, and thus generating leachate that could seep into and contaminate nearby groundwater. This action was selected because other actions had severe limitations. The contamination presently in the groundwater will be reduced over time by dilution. The municipal water supply will provide potable water for the County residents until the contaminant levels are reduced to acceptable limits.

There are no data currently available to evaluate the effectiveness of the remedial actions. However, based on the site conditions and the currently available information, the remedial actions selected and implemented should be effective in the long-term. The systems, if properly maintained, should effectively control the leachate and methane gas migration from the Taylor Road Landfill.

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